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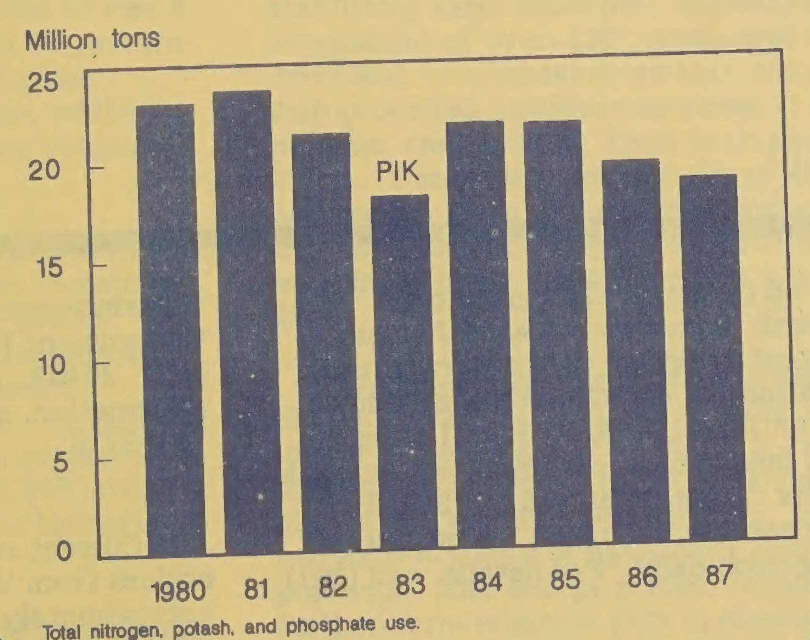
Inputs

Situation and Outlook Report

Fertilizer Use Declines



Total nitrogen, potash, and phosphate use.

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SUMMARY

U.S. fertilizer use is expected to decline about 5 percent during July 1986/June 1987, following a 10-percent drop the year before. Nitrogen, phosphate, and potash use are projected at 10, 3.9 and 4.8 million tons, respectively. Application rates per acre are projected to remain the same as last year. The decline in fertilizer use is tied to expected heavy farmer participation in acreage reduction programs. Commodity programs call for acreage reductions of 20 percent for feed grains, 35 percent for rice, 27.5 percent for wheat, and 25 percent for cotton. Corn acreage is likely to decline the most, as the 1987 feed grain program also includes an optional 15-percent paid land diversion.

U.S. nitrogen production could slow in 1987 with the drop in domestic use. However, increased exports will likely keep phosphate and potash output close to year-earlier levels. Fertilizer prices this spring are expected to average 10 percent below a year earlier, with 7 percent of the decline having occurred by last October.

Declining domestic demand and lower U.S. natural gas prices are likely to slow U.S. nitrogen imports, which are forecast to rise 4 percent in 1986/87, after climbing 11 percent a year earlier. Exports of diammonium phosphate are expected to increase, while weak domestic demand may reduce potash imports 5 percent.

Overall world fertilizer production should closely match consumption for the remainder of this decade, resulting in stable prices through 1990. World phosphate and potash production capacity is likely to exceed consumption into the next decade. Production capacity for nitrogen fertilizer is projected to grow more slowly than use during 1985-90, leading to increased nitrogen fertilizer prices early next decade.

U.S. farm pesticide use in 1987 will range from 405 to 445 million pounds active ingredient (a.i.) compared with 475 million pounds last year. Domestic pesticide supplies are expected to be down 4 percent. Pesticide manufacturers surveyed last fall indicated that prices may be up about 1 percent from last year. However, with heavy farmer participation in commodity programs, price competition at the retail level could be keen this spring.

Agricultural pesticide and fertilizer applications may be causing groundwater contamination in some parts of the United States, raising concerns about health and environmental risks. Potential contamination from pesticides is greatest along the Eastern Seaboard, the Gulf Coast, and the upper Midwest, while nitrate contamination of groundwater from fertilizers is predicted largely in the Great Plains and portions of the Northwest and Southwest. Areas with potential for both pesticide and nitrate contamination include portions of the Corn Belt, the Lake States, and the Northeast. Groundwater is the source of drinking water for over 50 million people in these regions.

Expenditures for new and used farm machinery in 1986 dropped an estimated $1.4 billion from a year earlier to $4.5 billion, due largely to continued financial difficulties in the farm sector. Farm machinery expenditures could level off in 1987 with a stabilizing farm economy. September inventories of over-100 horsepower two-wheel drive and four-wheel drive tractors and self-propelled combines declined 3, 33, and 30 percent, respectively, from year-earlier levels. Conversely, inventories of 40-99 horsepower farm tractors rose 9 percent. The United States registered a $114-million farm machinery trade deficit through third-quarter 1986.

World energy market conditions are characterized by abundant supplies and the lowest prices since 1979-80. U.S. refiners are forecast to pay close to $16 a barrel for crude oil in 1987, up slightly from 1986. Farmers can expect plentiful supplies of petroleum products. Soft energy prices, coupled with further farm program cuts in planted acreage, will likely lead to a $320-million reduction in farm fuel expenditures during 1987, compared with an estimated drop of $1.4 billion in 1986. Farm fuel use dropped 4 percent in 1986 and is likely to decline another 2 percent in 1987.

The drop in U.S. farmland values appears to be moderating, but is likely to continue in 1987, with declines anticipated throughout the Corn Belt, Southeast, Southwest, and Pacific Northwest. Positive forces in the land market include falling interest rates and production costs, and rising farm income due to Government payments. However, the large acreage for sale relative to demand, financial difficulties of some lenders, and uncertainty over future farm programs will put downward pressure on values for the remainder of the year.

FERTILIZER

Demand

U.S. plant nutrient consumption in 1986/87 will likely decline about 5 percent from a year earlier. Plant nutrient use is forecast at 10 million tons for nitrogen and 3.9 and 4.8 million tons, respectively, for phosphate and potash. This compares with a 10-percent drop in 1985/86, when farmers applied 10.4 million tons of nitrogen, 4.1 million tons of phosphate, and 5 million tons of potash.

Application rates per acre are expected to remain at 1985/86 levels. The primary reason for the decline in demand is that in 1986/87 farmer participation in commodity programs is expected to be heavy, allowing participants to qualify for deficiency payments. The feed grain program (corn, sorghum, barley, oats) calls for a 20-percent acreage reduction, rice a 35-percent reduction, wheat a 27.5-percent reduction, and cotton a 25-percent reduction. Additionally, a voluntary 15-percent paid land diversion program is part of the 1987 feed grain program, with corn acreage likely to decline the most. Participants will receive one-half of both diversion and projected deficiency payments in advance of planting, with 50 percent paid in cash and the other half in generic certificates. Target prices for feed grains and wheat will not change from last year, but loan rates will be lower.

Exports of nitrogen fertilizer during 1986/87 could be close to year-earlier levels, while phosphate exports are forecast to rise 10 percent. The increase in phosphate exports will depend upon a recovery in diammonium phosphate (DAP) exports, particularly shipments to China. Exports of diammonium phosphate to India may decline, but could be offset by increased exports to Western Europe and Latin America. The increase in diammonium phosphate exports will add to nitrogen exports, but declines in shipments of other nitrogen fertilizer materials are likely to offset these gains. Potash exports should be up in 1986/87 if current gains in shipments to Asian countries more than offset declines in shipments to Latin America.

Supplies

Domestic supplies of all fertilizers are expected to be ample in 1986/87. Although operating rates are down, available capacity is adequate to meet reduced needs. Anhydrous ammonia production capacity, estimated at 17.5 million tons, is operating at 75 percent, while the 11.3 million tons of wet-process phosphoric acid capacity is operating at 77 percent. U.S. potash capacity (1.8 million tons) is operating at an 84-percent rate and Canadian capacity (13 million tons) is operating at 50 percent.

A year earlier, anhydrous ammonia and wet-process phosphoric acid plants operating rates were over 85 percent, while U.S. and Canadian potash capacity operating rates were 77 and 53 percent, respectively. In 1986/87, gains in operating rates of phosphate and potash production capacity will depend upon substantial increases in exports.

U.S. nitrogen production could fall about 10 percent in 1986/87 primarily because of the decline in domestic use. (table 1). However, nitrogen imports will rise at a slower 4-percent rate compared to the 11-percent increase a year earlier. The decline in domestic fertilizer use will have a smaller impact on domestic production because of shifting trade patterns. Lower natural gas prices paid by many U.S. anhydrous ammonia producers will reduce costs and make U.S. products more competitive, slowing the penetration of imports. However, nitrogen producers in low-cost production areas outside

Table 1--U.S. supply-demand balance for years ending June 30

Item	Nitrogen 1985	Nitrogen 1986	Nitrogen 1987 1/	Phosphate 1985	Phosphate 1986	Phosphate 1987 1/	Potash 1985	Potash 1986	Potash 1987 1/
	Million nutrient tons								
Producers' beginning inventory	1.66	1.42	1.88	.81	.77	.63	.31	.31	.29
Production	13.90	12.17	10.97	11.34	2/ 9.45	2/ 9.39	1.56	1.20	1.25
Imports	3.73	4.15	4.30	2/ .14	2/ .11	2/ .11	5.48	4.81	4.57
Total available supply	19.29	17.74	17.15	12.29	10.33	10.13	7.35	6.32	6.11
Agricultural consumption	11.50	10.40	10.00	4.70	4.10	3.90	5.60	5.00	4.82
Exports	3.20	2.05	2.10	2/ 5.53	2/ 3.16	2/ 3.46	.59	.49	.55
Total agricultural and export demand	14.70	12.45	12.10	10.23	7.26	7.36	6.19	5.49	5.37
Producers' ending inventory	1.42	1.88	1.90	.77	.63	.70	.30	.29	.30
Available for non-agricultural use	3.17	3.41	3.15	1.29	2.44	2.07	.86	.54	.44

1/ Forecast. 2/ Does not include phosphate rock. In addition, because exports of superphosphoric acid are no longer reported, 1986 and 1987 export statistics are understated compared to 1985 and earlier years.

Source: (1, 2, 5, 6, 7).

Table 2--U.S. production of fertilizer nutrients for years ending June 30

Material	1985	1986 1/	Annual change
	Thousand tons		Percent
Nitrogenous fertilizers: 2/			
Anhydrous ammonia 3/	16,959	14,876	-12
Ammonium nitrate, solid	2,389	2,025	-15
Urea 3/	7,219	6,085	-16
Nitrogen solutions	3,260	2,837	-13
Phosphate fertilizers: 4/			
Normal and enriched superphosphate	103	69	-33
Triple superphosphate	1,145	1,093	-5
Diammonium phosphate	5,620	3,903	-31
Other ammonium phosphates	1,111	786	-29
Total	7,979	5,851	-27
Wet-process phosphoric acid 5/	10,559	8,823	-16
Muriate of potash: 6/			
United States	1,559	1,210	-22
Canada	8,029	7,187	-11

1/ Preliminary. 2/ Total not listed because nitrogen solutions are in 1,000 tons of N, while other nitrogen products are in 1,000 tons of material. 3/ Includes material for nonfertilizer use. 4/ Reported in 1,000 tons P_2O_5. 5/ Includes merchant acid. 6/ Reported in 1,000 tons of K_2O.

Source: (1, 7).

the United States will continue to compete effectively with U.S. producers.

In 1985/86, nitrogen fertilizer production decreased in response to less domestic use and a higher net import balance. Anhydrous ammonia production declined about 12 percent to 14.9 million tons (table 2). Production of ammonium nitrate, urea, and nitrogen solutions declined 13 to 16 percent.

In 1986/87, phosphate fertilizer production will approach year-earlier levels as increased exports offset the decline in domestic use resulting from fewer corn acres being fertilized. Total output of selected phosphate fertilizer materials in 1985/86 was down 27 percent from a year earlier. Diammonium phosphate production declined 31 percent after a 10-percent increase the preceding year. In comparison, triple superphosphate production fell only about 5 percent, reflecting a less dramatic decline in superphosphate exports.

Lower potash prices and lower freight rates have stimulated purchases by importing countries. U.S. producers have shared in the increased demand and, if current higher potash exports continue throughout 1986/87, U.S. producers may need to increase production,

Table 3--Average U.S. farm prices for selected fertilizer materials 1/

Year		Anhydrous ammonia (82%)	Triple superphosphate (44-46%)	Diammonium phosphate (18-46-0%)	Potash (60%)	Mixed fertilizer (6-24-24%)
		Dollars per ton				
1983:	May	237	214	249	143	206
1984:	May	280	231	271	147	217
1985:	May	252	203	240	128	192
	October	237	195	229	113	182
	December	233	192	224	109	177
1986:	April	225	190	224	111	179
	October	174	182	205	107	173

1/ Based on a survey of fertilizer dealers conducted by the National Agricultural Statistics Service, USDA.

ending a 6-year decline. U.S. potash imports will decline about 5 percent, but Canadian suppliers will maintain their share of the U.S. market.

Farm Prices

The expected decline in U.S. fertilizer demand in 1986/87 along with plentiful supplies should reduce farm fertilizer prices. Spring 1987 fertilizer prices are expected to average 4 percent below October 1986 prices and 10 percent below year-earlier levels. Increased phosphate and potash exports could, however, limit price declines primarily to nitrogen fertilizer materials.

Declines in fertilizer prices in 1987 would continue a trend that started in 1984. Between May 1984 and April 1986, fertilizer prices declined about 15 percent. Prices fell an additional 7 percent between April and October 1986. October 1986 nitrogen fertilizer prices were down the most from year-earlier levels with anhydrous ammonia prices down 27 percent. Potash and triple superphosphate prices declined 4 percent between April and October 1986 (table 3).

Fertilizer Trade

Fertilizer import volume in 1985/86 rose slightly, while value fell about 15 percent (table 4). Imports totaled approximately 16.2 million tons valued at $1.3 billion. Fertilizer exports were down about 22 percent to 21.7 million tons (table 5). Asian countries were the top customers for U.S. fertilizer followed by Latin America. India, for example, took about 13 percent of total U.S. plant nutrient exports. On the import side, Canada was the leading supplier, providing a substantial share of nitrogen imports and almost all the potash imports.

Nitrogen

Plentiful world fertilizer supplies and sagging demand created intense competition in world nitrogen markets. The inability of the U.S. industry to effectively compete with foreign producers because of higher feedstock costs caused nitrogen exports to fall and imports to increase. The falloff in diammonium phosphate exports also contributed to lower nitrogen exports for the year ending June 30, 1986.

According to U.S. Department of Commerce statistics, a 56-percent increase in urea imports accounted for most of the increase in nitrogen fertilizer imports. Although anhydrous ammonia imports were down 5 percent, the 2.8 million tons of anhydrous ammonia material imported accounted for about 2.3 million tons of nitrogen or 56 percent of the 4.2 million nutrient tons of nitrogen imports. Urea accounted for another 34 percent and nitrogen solutions, ammonium nitrate, and ammonium sulfate accounted for the remaining 10 percent.

Canada remained the most important supplier of nitrogen fertilizer, providing about

40 percent of U.S. imports. The Soviet Union was the second-ranking supplier, accounting for 24 percent, while Trinidad-Tobago and Romania provided 10 and 7 percent, respectively. Mexico's importance as a U.S. supplier continued to diminish with its 1985/86 share dropping to 3 percent.

Canada increased its share of U.S. anhydrous ammonia imports at the expense of all other suppliers. Canada's share rose from 34 to 43 percent, while the Soviet Union's share declined from 32 to 29 percent. Trinidad-Tobago's share also declined, dropping from 24 to 17 percent.

Table 4--U.S. imports of selected fertilizer materials for years ending June 30

Material	1984	1985	1986	1987 1/
	Thousand tons			
Nitrogen:				
Anhydrous ammonia	3,259	2,956	2,815	913
Urea	2,083	1,990	3,105	1,273
Ammonium nitrate	494	542	601	128
Ammonium sulfate	354	370	343	90
Sodium nitrate	108	147	128	23
Calcium nitrate	164	155	128	65
Nitrogen solutions	308	197	284	136
Other	125	253	147	67
Total	6,895	6,610	7,551	2,695
Phosphate:				
Ammonium phosphates	188	201	152	50
Crude phosphates	8	11	349	146
Phosphoric acid 2/	*	1	*	*
Normal and triple superphosphate	11	7	2	*
Other	4	2	2	1
Total	211	222	505	197
Potash:				
Potassium chloride	8,574	8,893	7,907	2,553
Potassium sulfate	68	68	53	15
Potassium nitrate 3/	43	75	79	16
Total	8,685	9,036	8,039	2,584
Mixed fertilizers	134	152	126	17
Total	15,925	16,020	16,221	5,493
	Billion dollars			
Total value 4/	1.54	1.51	1.29	.40

* = Less than 1,000 tons.

1/ Preliminary data for July-November 1986. 2/ Includes all forms of phosphoric acid. 3/ Includes potassium sodium nitrate. 4/ Value by fertilizer material in appendix table 1.

Source: (6).

Canada supplied about a third of the 3.1 million tons of urea imported by the United States in 1985/86. Another third came from the Soviet Union and Romania.

Anhydrous ammonia, urea, and diammonium phosphate exports dropped 29, 48, and 46 percent, respectively, accounting for most of the drop in nitrogen fertilizer exports (table 5). Diammonium phosphate exports accounted for the largest share (37 percent) of the 2.1 million nutrient tons of

Table 5--U.S. exports of selected fertilizer materials for years ending June 30

Material	1984	1985	1986	1987 1/
	Thousand tons			
Nitrogen:				
Anhydrous ammonia	390	1,069	759	341
Urea	1,034	1,388	718	268
Ammonium nitrate	19	34	188	42
Ammonium sulfate	672	829	721	605
Sodium nitrate	17	21	19	6
Nitrogen solutions	17	7	114	15
Other	53	58	62	21
Total	2,202	3,406	2,581	1,298
Processed phosphate:				
Normal superphosphate	41	4	4	1
Triple superphosphate	1,140	1,556	1,308	697
Diammonium phosphate	5,501	7,896	4,287	2,474
Other ammonium phosphate	500	544	542	249
Phosphoric acid 2/	1,570	1,515	594	434
Total	8,752	11,515	6,735	3,855
Phosphate rock 3/	13,448	11,694	11,294	3,823
Potash:				
Potassium chloride	567	795	602	312
Potassuim sulfate	97	88	135	98
Other	276	233	241	110
Total	940	1,116	978	520
Mixed fertilizers	140	99	70	21
Total	25,482	27,830	21,658	9,517
	Billion dollars			
Total value 3/	2.3	2.9	5/	5/

1/ Preliminary data for July-November 1986. 2/ Prior to 1986, phosphoric acid exports included both wet-process phosphoric acid and superphosphoric acid. Superphosphoric acid reports were discontinued after June 1985; 1986 data is no longer comparable with 1985 and earlier years. 3/ Effective January 1984, phosphate rock exports include a small tonnage of miscellaneous fertilizers. 4/ Value by fertilizer material in appendix table 2. 5/ Not available.

Source: (5).

nitrogen exported. Anhydrous ammonia accounted for 30 percent and urea accounted for 16 percent. Ammonium nitrate and ammonium sulfate accounted for another 10 percent.

In 1985/86, the Republic of Korea, Spain, and Tunisia were the largest customers for U.S. anhydrous ammonia, while Canada, Hong Kong, and Chile purchased the most urea.

Based on purchases of diammonium phosphate and various nitrogen fertilizers, India accounted for 11 percent of U.S. nitrogen exports, while the Republic of Korea and Belgium-Luxembourg accounted for 10 and 7 percent, respectively.

Phosphate

Phosphate fertilizer exports in 1985/86 were affected by market conditions a year earlier. In 1984/85, low phosphate fertilizer prices resulted in record U.S. exports. Imports by several Asian countries during 1984/85 exceeded use, resulting in a stock buildup at the beginning of 1985/86. In response to ample stocks, China, India, Taiwan, and Japan began restricting imports. Exports to China also were affected by that country's policy to conserve foreign exchange. Consequently, phosphate exports, excluding superphosphoric acid, declined 38 percent in 1985/86 to about 3.2 million nutrient tons.

Most of the decline in phosphate exports was due to a 46-percent drop in diammonium phosphate exports. Diammonium phosphate shipments to China dropped by 1.3 million tons, as China essentially removed itself from the market in 1985/86. Exports to India, Taiwan, and Japan were down 61 percent, accounting for a 1.9-million-ton drop.

India was the largest purchaser of U.S. phosphate fertilizer in 1985/86, accounting for almost a fifth of U.S. phosphate exports and about a fourth of diammonium phosphate exports. Other important customers were Canada with 8 percent, Italy and Belgium-Luxembourg each with 7 percent, and Pakistan with 6 percent. Although data on exports of superphosphoric acid to the Soviet Union are not available, it is believed that the Soviets are a large customer for U.S. phosphate fertilizer.

U.S. phosphate rock exports declined about 3 percent to 11.3 million tons, continuing a trend toward shipping processed phosphate fertilizer rather than rock. Since total world phosphate rock exports also declined, the U.S share of total world phosphate rock exports has shown only a slight decline.

Potash

U.S. potassium chloride imports declined about 11 percent in 1985/86 in response to the decline in domestic consumption. Potassium chloride accounted for almost all potash imports, with Canada providing 94 percent of the total (table 4). Israel was the only other significant supplier, with 4 percent.

U.S. exports of potassium fertilizer materials declined about 12 percent in 1985/86. Less than 1 million tons were shipped, with potassium chloride accounting for 62 percent of the total (table 5). Potassium sulfate, which increased 53 percent and accounted for 14 percent of potassium materials, has gained some importance as an export item.

Fertilizer Use Estimates

In the year ending June 30, 1986, about 44 million tons of fertilizer materials were used in the United States and Puerto Rico, 10 percent less than in 1984/85 (table 6) as corn acres fell 8 percent and planted acres fell 5 percent. In terms of total plant nutrients, use was down 10 percent to 19.6 million tons. Nitrogen use decreased about 10 percent to 10.4 million tons. Phosphate use amounted to 4.1 million tons, 13 percent below a year earlier. Potash consumption, at 5 million tons, was down 11 percent.

Even though the least fertilized acres were withdrawn from production in 1986, due to heavy participation in the farm program, fertilizer application rates on corn were down, with nitrogen application rates declining the most (table 7). Declines in loan rates and market prices, while offset somewhat by lower fertilizer prices, apparently led to lower application rates. In addition, the severe financial plight of some Corn Belt farmers apparently reduced their fertilizer purchases. Generally, application rates on cotton,

Table 6--U.S. fertilizer consumption 1/

Year ending June 30 2/	Total fertilizer materials	Primary nutrient use				Share of 1977 total nutrient use
		N	P_2O_5	K_2O	Total 3/	
		Million tons				Percent
1976	49.2	10.4	5.2	5.2	20.8	94
1977	51.6	10.6	5.6	5.8	22.1	100
1978	47.5	10.0	5.1	5.5	20.6	93
1979	51.5	10.7	5.6	6.2	22.6	102
1980	52.8	11.4	5.4	6.2	23.1	105
1981	54.0	11.9	5.4	6.3	23.7	107
1982	48.7	11.0	4.8	5.6	21.4	97
1983	41.8	9.1	4.1	4.8	18.1	82
1984	50.1	11.1	4.9	5.8	21.8	99
1985	49.1	11.5	4.7	5.6	21.7	98
1986	44.0	10.4	4.1	5.0	19.6	89

1/ Includes Puerto Rico. Detailed State data shown in appendix table 3. 2/ Fertilizer use estimates for 1976 to 1984 are based on USDA data, while 1985 and 1986 are TVA estimates. 3/ Totals may not add due to rounding.

Table 7--Fertilizer use on selected U.S. field crops 1/

Crop, year	Total U.S. planted acreage	Acres receiving				Application rates		
		Any fertilizer	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	Million	Percent				Pounds per acre		
Corn for grain:								
1982	81.9	97	97	88	84	135	65	86
1983	60.2	96	97	88	83	137	64	85
1984	80.5	97	97	87	82	138	65	87
1985	83.4	98	97	86	79	140	60	84
1986	76.7	96	95	84	76	132	61	80
Cotton:								
1982	11.4	71	71	41	30	82	46	55
1983	7.9	68	68	44	30	81	45	52
1984	11.2	77	76	48	32	81	48	53
1985	10.9	76	76	50	34	80	46	52
1986	9.7	80	80	50	39	77	44	50
Soybeans:								
1982	70.9	30	17	27	29	17	43	68
1983	63.8	33	20	30	32	18	45	70
1984	67.8	34	20	30	32	17	46	72
1985	63.1	32	17	28	30	15	43	72
1986	61.8	33	18	29	31	15	43	71
All wheat:								
1982	86.2	70	70	45	18	59	37	41
1983	76.4	73	72	48	20	60	39	48
1984	79.2	76	76	49	17	62	37	46
1985	75.6	77	77	48	16	60	35	36
1986	72.0	79	79	48	19	60	36	44

1/ Detail for States by crop are found in appendix tables 4 through 7.

soybeans, and wheat were close to 1985 rates. Increases were limited to a modest gain in phosphate use on wheat and a significant gain in potash applicaton rates on wheat. In 1986/87, declines in phosphate and potash prices will offset declines in crop loan rates, leaving application rates near year-earlier levels. A sharper decline in nitrogen prices could bring some recovery in nitrogen application rates.

Corn

Fertilizer was applied on 96 percent of corn acres in 1985/86. Nitrogen use declined from a record 140 pounds per acre in 1984/85 to 132 pounds in 1985/86. Phosphate application rates increased from 60 to 61 pounds, but the percent of acres fertilized dropped from 86 to 84 percent. Potash application rates as well as percent of acres fertilized declined in 1985/86.

Cotton

About 80 percent of cotton acreage received some fertilizer in 1985/86, up from a year earlier because of an increase in the percent of acres fertilized with nitrogen and potash. The increase in proportion of cotton acres fertilized added to fertilizer use on cotton, but these increases were partially offset by fewer pounds applied per acre.

Soybeans

Fertilizer use on soybean acres increased in 1985/86. While the pounds of fertilizer applied per acre were about the same, the proportion of soybean acres fertilized increased for each of the three nutrients.

Wheat

In 1985/86, the proportion of wheat acres fertilized with nitrogen and potash increased, while the proportion fertilized with phosphate remained unchanged. Also, pounds of phosphate and potash applied per acre increased, with potash rates increasing substantially from 36 to 44 pounds.

Less fertilizer was used in all regions of the country in 1985/86 (table 8). Declines in total plant nutrient use ranged from 3 to 15 percent with the smallest decline in the Delta States and the largest decline in the Lake States. Small reductions in rice, cotton, and soybean acres in the Delta States had less impact on reduced fertilizer use than the substantial reduction in planted corn acres and lower fertilizer application rates in the Lake States. Nitrogen use declined the most in the Northeast, Lake States, and Pacific regions (table 9). Phosphate and potash use dropped the most in the Lake States and Southern Plains.

Table 8--Regional plant nutrient consumption for year ending June 30 1/

Region	1985	1986	Annual changes
	Thousand tons		Percent
Northeast	829	726	-12
Lake States	2,872	2,438	-15
Corn Belt	7,181	6,663	-7
Northern Plains	2,483	2,371	-5
Appalachia	1,695	1,496	-12
Southeast	1,657	1,475	-11
Delta States	970	945	-3
Southern Plains	1,643	1,422	-14
Mountain	911	820	-10
Pacific 2/	1,432	1,239	-14
U.S. total 3/	21,673	19,594	-10

1/ Includes N, P_2O_5, and K_2O. Totals may not add due to rounding. 2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 3.

Source: (2)

The proportion of fertilizers applied as multiple nutrient materials declined to 43 percent, while the proportion applied as a single nutrient increased to 57 percent (table 10).

World Fertilizer Review and Prospects

World plant nutrient production and use continued to expand in 1984/85, but use declined in 1985/86, due mainly to stagnant demand in Western Europe and reduced demand in North America. Reduced fertilizer demand necessitated a downward adjustment in fertilizer production plans.

Supplies

World plant nutrient supplies in 1984/85 increased about 11 percent to over 139 million

metric tons (table 11). Nitrogen supplies rose about 8 percent to 72 million tons, while phosphate supplies climbed about 15 percent to almost 38 million tons. Potash supplies increased about 12 percent to 29.4 million tons.

World supplies are expected to be up about 2 percent in 1985/86, reflecting production adjustments. Increases in nitrogen and potash production will be partially offset by declines in phosphate production.

Consumption

World fertilizer consumption in 1984/85 increased 4 percent from a year earlier to about 131 million metric tons (table 11). Nitrogen consumption rose more than 5

Table 9--Regional plant nutrient use for year ending June 30 1/

Region	1985	1986	Annual changes
	Thousand tons		Percent
Nitrogen:			
Northeast	312	262	-16
Lake States	1,211	1,059	-13
Corn Belt	3,443	3,120	-9
Northern Plains	1,837	1,751	-5
Appalachia	687	610	-11
Southeast	720	665	-8
Delta States	548	557	-2
Southern Plains	1,110	975	-12
Mountain	626	572	-9
Pacific 2/	987	855	-13
U.S. total 3/	11,480	10,425	-9
Phosphate:			
Northeast	229	200	-13
Lake States	612	508	-17
Corn Belt	1,474	1,383	-6
Northern Plains	521	504	-3
Appalachia	422	365	-14
Southeast	331	281	-15
Delta States	180	163	-9
Southern Plains	364	302	-17
Mountain	232	201	-13
Pacific 2/	288	247	-14
U.S. total 3/	4,652	4,154	-11
Potash:			
Northeast	288	264	-8
Lake States	1,048	871	-17
Corn Belt	2,264	2,160	-5
Northern Plains	126	116	-8
Appalachia	585	521	-11
Southeast	607	529	-13
Delta States	243	225	-7
Southern Plains	169	146	-14
Mountain	54	48	-11
Pacific 2/	157	137	-13
U.S. total 3/	5,541	5,015	-10

1/ Totals may not add due to rounding.
2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 3.

Source: (2).

Table 10--Average annual U.S. fertilizer use 1/

Year ending June 30 4/	Multiple nutrient 2/		Single nutrient 3/	
	Quantity	Share of total	Quantity	Share of total
	Million tons	Percent	Million tons	Percent
1976	23.0	47	26.2	53
1977	24.1	47	27.5	53
1978	22.1	47	25.4	53
1979	23.7	46	27.7	54
1980	23.3	44	29.5	56
1981	23.5	44	30.5	56
1982	20.9	43	27.8	57
1983	18.4	44	23.5	56
1984	21.2	42	28.9	58
1985	20.6	44	26.7	56
1986	18.1	43	24.2	57

1/ Includes Puerto Rico. 2/ Fertilizer materials that contain more than one primary nutrient. 3/ Materials that contain a single nutrient. 4/ Fertilizer use estimates for 1976 to 1984 are based on USDA data, while 1985 and 1986 are TVA estimates.

Table 11--World plant nutrient supply and consumption for years ending June 30

Plant nutrient	1984	1985	1986 1/
	Million metric tons		
Available supply: 2/			
Nitrogen	66.9	72.0	73.5
Phosphate	32.9	37.9	37.0
Potash	26.3	29.4	31.2
Total	126.1	139.3	141.7
Consumption:			
Nitrogen	66.9	70.5	70.2
Phosphate	32.9	34.3	33.0
Potash	25.4	25.9	26.4
Total	125.2	130.7	129.6

1/ Projected. 2/ Production less industrial uses and losses in transportation, storage, and handling.

Source: (3, 4).

percent to about 71 million tons, while phosphate consumption increased 4 percent to over 34 million tons. Potash use rose only 2 percent to almost 26 million tons.

World plant nutrient use declined an estimated 1 percent in 1985/86, due to reduced use in the United States and Latin America, Oceania, and the Near East.

Projections for 1986–91

According to FAO/World Bank forecasts done in 1986, world nitrogen, phosphate, and potash fertilizer consumption is expected to grow 18, 21, and 15 percent during 1986–91 (table 12). Fertilizer production and use are projected to grow the fastest in the developing and Asian centrally planned economies. In the developed countries, consumption of the various plant nutrients is expected to grow 6 to 13 percent by 1991, down from earlier projections that ranged above 10 percent. Declines in fertilizer use in the United States and stable demand in Western Europe early in 1986–91 will slow the growth in world fertilizer use and affect nitrogen and phosphate production rates. Also, increased North American potash exports will support growth in potash production in the developed countries, while a decline in Eastern European and Soviet Union potash exports could result in a slight decline in production in those areas.

In the developing countries, the supply potential of the three plant nutrients will be up 37 to 46 percent by 1991, while consumption will be up about a third. The rapid increase is attributable to the goals of many developing countries to move toward self-sufficiency in food production and, if possible, self-sufficiency in fertilizer production.

Nitrogen and phosphate production in the developed countries is expected to grow 6 to 8 percent, respectively, while potash production is projected to be up 13 percent. Most of the increased production planned in the developed countries will come from greater Canadian potash and nitrogen production for the export market. Given a recovery in world fertilizer prices, Israel is expected to increase potash production, and France, the Netherlands, and the United Kingdom could increase nitrogen production. In the United States, any increase

Table 12--Projected 1986-91 change in world fertilizer supply and consumption 1/

World regions	Nitrogen	Phosphate	Potash
	Percent increase		
Supply potential:			
Developed market economies	6	8	13
Developing market economies	38	37	46
Eastern Europe and the Soviet Union	4	11	-6
Centrally-planned countries of Asia	10	50	136
Total	12	17	5
Consumption:			
Developed market economies	6	8	13
Developing market economies	35	39	32
Eastern Europe and the Soviet Union	22	12	14
Centrally-planned countries of Asia	15	79	139
Total	18	21	15

1/ Detail in appendix table 8.

Source: (3, 4).

in phosphate fertilizer production will depend heavily on an increase in phosphate exports.

In the Asian and Eastern European centrally planned countries, greater nitrogen production capacity will be limited mostly to those additions built in China. Production gains are also expected in the Soviet Union, where plant operating rates are increasing.

In the developing countries, nitrogen production is expected to increase the most near natural gas reserves located in India, Indonesia, Saudi Arabia, Mexico, and Trinidad-Tobago. About a third of the increased production capacity being built in developing countries will probably be in India, with another fifth in both the Latin American and Near East regions, and about 7 percent in Africa.

During 1986–91, world phosphate fertilizer production will center primarily in the United States, Soviet Union, and Morocco. About a third of the phosphoric acid supply capability will be in the United States. Another 17 percent will be located in the Soviet Union, and 7 percent will be in Morocco. Also, increased phosphate

production in India, China, Mexico, Tunisia, and Brazil will add to world supplies.

During 1986/91, world potash production potential is expected to increase about 5 percent. Canada will add the most capacity, with other additions in Israel, Jordan, Brazil, and China. Although world potash consumption is expected to increase about 15 percent during 1986-91, supplies are expected to be adequate because of increased operating rates. Operating rates worldwide are forecast to increase from 67 percent in 1986 to 75 percent in 1991.

Projected regional shares of world fertilizer supply and demand indicate a continued shift in production and use away from the developed countries to the developing countries. The centrally planned countries' share of world fertilizer production, especially nitrogen and potash, will diminish, but their share of consumption of all nutrients will remain almost unchanged (table 13).

Western Europe, Asia, and Africa are projected to be nitrogen-deficit areas through 1991. Latin America, the Near East, Eastern Europe, and the Soviet Union will be surplus areas, as countries with plentiful natural gas resources produce nitrogen fertilizer for export. North America will be a marginally surplus area because of increased Canadian production and less optimistic forecasts of nitrogen fertilizer use in the United States.

The availability of nitrogen production capacity relative to projected demand should provide for adequate supplies until the end of the decade. Without a sharp increase in energy prices, world nitrogen fertilizer prices should remain fairly stable or decline only slightly through 1990. However, surplus production capacity is beginning to fall off as planned additions to production capacity early in the next decade indicate the possibility that supplies will not meet demand without increases in the price of nitrogen fertilizer.

Table 13—Projected regional shares of world fertilizer supply potential and demand 1/

World regions	Nitrogen		Phosphate		Potash	
	1986	1991	1986	1991	1986	1991
	Percent					
Supply potential:						
Developed market economies--	31.3	29.3	50.4	46.6	53.1	56.9
North America	15.3	14.8	25.5	25.0	32.4	35.2
Western Europe	14.1	13.3	16.3	14.1	16.9	16.5
Oceania	0.5	0.4	3.7	3.4	0	0
Other countries	1.4	0.8	4.9	4.1	3.8	5.2
Developing market economies--	20.5	25.1	20.1	23.4	1.9	2.6
Africa	0.3	0.8	7.2	9.4	0	0
Latin America	5.6	5.9	4.3	4.8	0	0.4
Asia	14.6	18.4	8.6	9.2	1.9	2.2
Eastern Europe and the Soviet Union	30.8	28.5	23.6	22.5	44.9	40.2
Centrally-planned countries of Asia	17.4	17.1	5.8	7.5	0.1	0.3
Consumption:						
Developed market economies--	33.0	29.7	37.3	32.1	45.2	41.3
North America	15.5	14.0	14.3	12.3	20.1	18.5
Western Europe	15.3	13.7	16.1	13.7	21.1	19.0
Oceania	0.5	0.5	3.4	3.0	1.0	1.0
Other countries	1.7	1.5	3.5	3.1	3.0	2.8
Developing market economies--	23.5	26.7	23.3	26.4	14.2	16.3
Africa	1.2	1.2	1.8	1.9	1.1	1.2
Latin America	4.5	5.5	6.7	7.6	6.1	7.1
Asia	17.8	20.0	14.8	16.9	7.0	8.0
Eastern Europe and the Soviet Union	22.1	22.8	30.3	28.0	38.6	38.2
Centrally-planned countries of Asia	21.4	20.8	9.1	13.5	2.0	4.2

1/ Forecasts for year ending June 30.

Source: (3).

Generally, the developed countries are projected to have a surplus of phosphate fertilizer, while Eastern Europe, the Soviet Union, and Asia are expected to be deficit areas. Africa, because of Moroccon and Tunisian production, will have the largest surpluses. Asia is expected to be the largest deficit area.

North America, because of increased Canadian production, is projected to have the largest potash surplus. Although Soviet production will decline because of a flooded mine, Eastern Europe and the Soviet Union will still be major surplus areas. Western Europe, Asia, Africa, and Latin America are projected to be deficit areas. World supplies of phosphate and potash fertilizer are expected to be adequate well into the next decade.

World Trade Developments

Existing nitrogen trade patterns will probably carry through into the next decade. Eastern Europe, the Soviet Union, and Romania will continue to supply nitrogen fertilizer to the United States, Western Europe, and Asia. Increased nitrogen fertilizer production in Trinindad-Tobago will go primarily to U.S. and Western European markets, while surplus nitrogen from the Near East will probably move to the Asian market.

With a recovery in fertilizer prices, Western Europe could import less and become more self-sufficient in nitrogen fertilizers. New, cost-effective production capacity could increase home production and provide the Western European market with a product that is more price-competitive with imported material.

Since production from new nitrogen fertilizer production capacity is intended primarily for shipment to the United States, Canada has delayed adding anhydrous ammonia and urea production capacity in deference to the depressed U.S. nitrogen fertilizer market. A recovery in the U.S. nitrogen fertilizer market would probably encourage Canadian producers to add production capacity.

The Asian market is expected to be the most active of the regional phosphate markets. Since Asian countries are expected to produce only a small share of the phosphate fertilizer used, they must meet growing demand with more imports. The African and U.S. phosphate fertilizer industries will be in competition to fill this growing market.

Western Europe, for the most part, offers limited scope for increased phosphate fertilizer use, but less developed parts of the region--Greece, Spain, Portugal, and Turkey--will likely experience increased consumption.

Eastern Europe continues to require phosphate fertilizer, but the effectiveness of local distribution systems and the ability to finance imports and investments in distribution and production will continue to constrain consumption levels.

In Latin America, the principal consumers of phosphate fertilizer, Mexico and Brazil, are due to bring new plants into production. Larger domestic production will encourage increased consumption.

Canada, the German Democratic Republic, and the Soviet Union are the dominant potash exporters, and Canada is expected to gain further dominance. A greater proportion of Eastern Europe's production will go for domestic use, and Canada is expected to further penetrate the large Indian and Chinese markets.

World Fertilizer Prices

Ample supplies and less use caused fertilizer prices to decline in 1985/86. Generally, declines were greatest for nitrogen and potash fertilizers. Anhydrous ammonia, urea, and potassium chloride prices declined throughout the year as producers oversupplied the market.

The availability of low-priced Eastern European urea was the major factor contributing to declines in nitrogen fertilizer prices. Eastern European suppliers continued to make products available in the face of less use, offsetting reduced production in the United States.

Large inventories held by Canadian producers and intense competition between U.S., Canadian, and Israeli producers contributed to the decline in potash fertilizer prices, particularly in Western Europe and

Latin America. The unpredictability of Chinese purchasing patterns also affected potash market price expectations.

U.S. phosphate producers attempted to support phosphate fertilizer prices by cutting production, but reduced purchases by various Asian countries, especially China, caused prices to drift lower during 1986.

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PESTICIDES

Demand

U.S. farm demand for pesticides in 1987 is expected to be down from 1986 because of heavy farmer participation in commodity programs. Pesticide use on major field crops could range from 405 to 445 million pounds active ingredient (a.i.) (table 14). This is a 6- to 15-percent reduction from the 475 million pounds used in 1986. Herbicides will account for 85 percent of total pesticide use, followed by insecticides at 12 percent. Corn and soybean production account for most of the herbicide use while corn and cotton dominate insecticide use. Fungicides are most commonly used in peanut production.

Supplies

Domestically produced pesticides available for U.S. farm use are projected to be down 4 percent from 1986 but adequate to meet 1987 crop needs (table 15). Production is expected to be down 8 percent but inventory carryover into the 1987 growing season is projected to be up 17 percent. Overall pesticide exports are projected to be up 2 percent from 1986.

Domestic herbicide supplies for 1987 are forecast at 480 million pounds (a.i.). Manufacturers' inventories are up 12 percent, and as a result, herbicide production is being trimmed 7 percent. Insecticide supplies will be down 9 percent in 1987 as the 12-percent decline in production more than offsets the 13-percent increase in inventory carryover. Fungicide supplies are forecast to be up 32 percent due to a large inventory carryover and reduced exports.

Overall domestic plant capacity utilization is projected at 59 percent for 1987, down 6 points from 1986 (table 16). Fungicide plants are expected to operate at 53 percent of capacity, down from 61 percent in 1986. Herbicide plants will operate at 59 percent of capacity, 5 points lower, while insecticide plants will operate at 61 percent, 2 points lower than year-earlier levels. Some plant expansion in 1987 will occur in insecticide production but, similar to the past several years, little for herbicides and fungicides (table 17).

Pesticide prices quoted by manufacturers for the 1987 crop season are up slightly from last year (table 18). Manufacturers have reduced available supplies, reflecting the anticipated decrease in crop acres planted under the 1985 Food Security Act. If the price increase is realized at the retail level this coming spring and summer, it would reverse the general decline in pesticide prices over the last 4 to 5 years.

Table 14--Projected pesticide use on major U.S. field crops

Crop	1986 planted acreage	Projected 1987 use		
		Herbicides	Insecticides	Fungicides
	Million	Million pounds (active ingredients)		
Row:				
Corn	76.6	181 - 200	16.9 - 18.7	.05
Cotton	9.6	16 - 17	15.2 - 16.8	.16
Grain sorghum	15.0	12 - 14	2.0 - 2.2	0.00
Peanuts	1.5	5 - 6	1.1 - 1.2	5.46
Soybeans	61.8	101 - 112	8.9 - 9.8	.06
Tobacco	.6	1 - 2	2.2 - 2.4	.30
Total	165.1	316 - 351	46.3 - 51.1	6.03
Small grains:				
Barley and oats	27.7	7 - 8	.2 - .3	0.00
Rice	2.3	10 - 11	.4 - .5	.06
Wheat	71.8	14 - 15	1.8 - 2.0	.79
Total	101.8	31 - 34	2.4 - 2.8	.85
Total	266.9	347 - 385	48.7 - 53.9	6.88

Table 15--U.S. pesticide production, inventories, exports, and domestic supply

Item	Quantity (active ingredients) 1/		Projected change, 1986-1987
	1986	Projected 1987	
	Million pounds		Percent
Herbicides:			
Production	482	449	-7
Carryover	147	165	12
Exports	126	134	6
Domestic supply	503	480	-5
Insecticides:			
Production	191	168	-12
Carryover	53	60	13
Exports	74	74	-
Domestic supply	170	154	-9
Fungicides:			
Production	62	61	-2
Carryover	5	14	180
Exports	29	25	-14
Domestic supply	38	50	32
All pesticides:			
Production	735	678	-8
Carryover	205	239	17
Exports	229	233	2
Domestic supply	711	684	-4

1/ Production for surveyed manufacturers only. These firms produce a major portion of all U.S. farm pesticides.

Source: USDA survey of basic pesticide manufacturers, October 1986.

Table 16--U.S. pesticide production capacity utilization rates

Year	Herbicides	Insecticides	Fungicides	All pesticides
	Percent			
1978	81	87	83	83
1979	74	85	84	80
1980	77	79	84	78
1981	74	72	68	73
1982	84	68	70	80
1983	66	33	71	54
1984	67	29	73	52
1985	62	56	66	61
1986	64	63	61	65
1987 1/	59	61	53	59

1/ Projected.

Source: USDA annual survey of basic pesticide manufacturers, October 1986.

Aggregate herbicide prices declined 13 percent from $4.62 per pound (a.i.) in 1982 to $4.05 per pound in 1986. Insecticide prices during this period have fluctuated between $10 and $10.50 per pound (a.i.). The price of atrazine, a major corn herbicide, declined about 25 percent between 1982 and 1985 but rose 2 percent in 1986. The price of trifluralin, a major soybean and cotton herbicide, declined more than 25 percent from 1982 to 1986. Wheat farmers who use 2,4-D for weed control enjoyed a 19-percent price decline during 1982-1986. The major change in insecticide prices during the period was the 25-percent decline in synthetic pyrethroid prices from $68 per pound (a.i.) to $51 per pound.

Table 17--U.S. pesticide production capacity expansion

Year	Herbicides	Insecticides	Fungicides	All pesticides
	Percent			
1977/78	3	4	3	3
1978/79	4	3	22	4
1979/80	2	1	3	2
1980/81	3	0	0	2
1981/82	4	7	0	5
1982/83	*	*	na	*
1983/84	0	6	0	1
1984/85	1	1	0	1
1985/86	1	1	1	1
1986/87 1/	1	3	0	1

* Less than 1 percent.
na -- not available.

1/ Projected.

Source: USDA annual survey of basic pesticide manufacturers, October 1986.

Table 18--Pesticide price changes

Item	1984/85 1/	1985/86 1/	Projected 1986/87 2/
	Percent		
Herbicides	-2	*	1
Insecticides	5	-2	1
Fungicides	na	na	0

*--Less than 1 percent.
na -- not available.

1/ April prices paid by farmers. 2/ Quoted manufacturer prices.

Source: USDA annual survey of basic pesticide producers, October 1986.

1986 Pesticide Use

Corn for Grain

Herbicides were used on 96 percent of the surveyed corn acreage in 1986, similar to the 2 previous years (table 19).

South Dakota treated the fewest corn acres for weed control at 81 percent. Insecticides were used on 41 percent of the corn acreage, compared with 45 percent in 1985. Insecticide use was greatest in Nebraska, where 59 percent of the corn acreage was treated. In contrast, South Dakota and Minnesota treated only 20 percent of their corn acreage. Most insecticides were

Table 19--Pesticide use on row crops, 1986 1/

Crop and State	Acres treated with: Herbicides	Insecticides
	Percent	
Corn:		
Illinois	97	45
Indiana	96	43
Iowa	99	43
Michigan	97	48
Minnesota	96	21
Missouri	98	32
Nebraska	89	59
Ohio	99	30
South Dakota	81	20
Wisconsin	98	46
1986 Average	96	41
1985 average	96	45
1984 average	95	42
Soybeans:		
Alabama	83	15
Arkansas	90	1
Georgia	89	28
Illinois	98	3
Indiana	95	nr
Iowa	99	2
Kentucky	94	nr
Louisiana	100	9
Minnesota	98	nr
Mississippi	98	2
Missouri	95	2
Nebraska	87	nr
North Carolina	86	55
Ohio	95	nr
Tennessee	100	nr
1986 average	96	4
1985 average	95	7
1984 average	94	8

nr -- none reported.

1/ States in survey planted 58.9 million acres of corn (77 percent of U.S. total); 52.4 million acres of soybeans (85 percent).

used for control of corn rootworm larvae but some were used to control European cornborers, cutworms, and mites.

In the 10 surveyed States, herbicides were applied to 55 million acres of corn in 1986 (table 20). On average, the corn acreage treated received 1.3 herbicide applications. Acre-treatments ranged from 1 in Michigan to a high of 1.4 in Minnesota. In most multiple application cases, preplant or preemergence treatments were followed by a postemergence application, but in some cases the same acreage received more than one postemergence application.

Atrazine + alachlor was the most commonly used herbicide, and was applied to 20 percent of all corn acres treated (table 20). Both active ingredients control many broadleaf and grass weeds, but applied in combination, the control spectrum is broadened. Atrazine was also used extensively in combination with metolachlor or

Table 20--Selected herbicides used in corn production, 1986

Item	IL	IN	IA	MI	MN	MO	NE	OH	SD	WI	Total
					Thousand						
Acres treated with herbicides	10190	5785	12180	2810	6145	2510	5495	3855	2575	3825	55370
					Percent						
Active ingredients:											
Single materials--											
Atrazine	16	14	6	21	15	28	25	13	11	30	16
Dicamba	9	2	9	3	8	1	3	9	13	5	7
Cyanazine	2	2	4	1	8	4	3	4	4	5	4
Bromoxynil	1	1	6	1	2	3	3	2	3	–	3
Metolachlor	10	2	14	1	10	–	1	2	8	1	7
EPTC	1	–	3	–	9	–	2	1	8	–	3
Alachlor	10	5	14	3	26	7	16	8	38	5	14
2,4-D	8	3	5	1	14	4	8	7	15	1	7
Propachlor	1	1	4	1	5	–	–	–	6	1	2
Other	5	7	3	3	2	1	4	4	1	5	4
Tank mixes--											
Atrazine + cyanazine	7	7	10	9	1	19	5	5	3	5	10
Atrazine + metolachlor	15	18	12	9	3	13	13	24	2	8	14
Atrazine + alachlor	15	23	11	29	7	24	19	21	2	28	20
Atrazine + butylate	10	10	1	1	1	2	2	2	–	1	4
Atrazine + others	5	6	5	8	5	4	3	5	4	2	5
Dicamba + 2,4-D	3	1	7	–	7	–	2	4	1	1	4
Dicamba + others	–	–	1	–	8	–	1	2	2	4	2
Cyanazine + alachlor	3	1	5	2	4	2	1	3	3	6	3
Cyanazine + others	2	1	5	2	5	1	1	3	1	7	3
Other 2-way	3	4	1	1	–	2	2	4	–	–	2
Atrazine + alachlor + cyanazine	1	4	2	4	1	1	–	1	1	–	2
Other 3-way	3	3	6	3	1	1	1	5	–	2	3
					Number						
Acre-treatments	1.3	1.2	1.3	1.0	1.4	1.2	1.2	1.3	1.3	1.2	1.3

cyanazine. Atrazine and alachlor dominated the active ingredients applied alone at 16 and 14 percent, respectively.

Specific active ingredient use varied considerably by State. Alachlor alone was not used extensively in Indiana, Michigan, Missouri, Ohio, and Wisconsin. Atrazine alone was used on only 6 percent of the corn acres treated with herbicides in Iowa. Metolachor use was most important in Illinois, Iowa, and Minnesota. Minnesota and South Dakota used EPTC to control quackgrass and shattercane. Dicamba, metolachlor, and 2,4-D were each used on 7 percent of the corn acreage treated with herbicides. They were applied postemergence to control broadleaf weeds that escaped a previous treatment. Use of these three active ingredients was most important in South Dakota.

Soybeans

In 1986, 96 percent of the soybean acreage in the surveyed States was treated with herbicides (table 19). Alabama had the fewest treated acres at 83 percent. Insecticides were used on only 4 percent of the soybean acreage, compared with 7 and 8 percent in 1985 and 1984, respectively. The reduction in insecticide use in 1986 occurred primarily in the Southeast and Delta, where many farmers felt it was not profitable to treat their drought-stressed soybeans.

In the 15 surveyed States, herbicides were applied to 51 million acres of soybeans in 1986 (table 21). Of the acreage treated, an average of 1.4 acre-treatments were made in 1986. Farmers in Nebraska, North Carolina, and Ohio averaged 1.2 acre-treatments on

Table 21--Selected herbicides used in soybean production, 1986

Item	AL	AR	GA	IL	IN	IA	KY	LA	MN	MS	MO	NE	NC	OH	TN	Total
								Thousand								
Acres treated with herbicides	650	3345	1115	8850	4050	8640	1040	1950	4890	2560	5425	2185	1455	3500	1550	51,205
								Percent								
Active ingredients:																
Single materials--																
Chloramben	2	-	-	3	2	7	-	-	8	-	1	3	-	11	-	4
Bentazon	6	7	4	17	12	12	7	-	10	4	9	4	-	4	11	9
Acifluorfen	9	2	2	-	1	-	5	3	2	6	1	-	10	8	4	2
Metolachlor	-	5	-	3	1	1	5	-	1	2	3	1	1	2	1	2
Fluazifop-butyl	3	6	-	2	1	1	11	8	-	4	1	-	-	-	4	2
Alachlor	14	8	12	7	8	6	-	4	8	-	6	13	18	3	-	7
Sethoxydim	-	2	2	4	4	2	2	2	2	13	1	-	4	1	9	3
Pendimethalin	15	11	7	6	1	6	4	15	2	20	9	7	6	-	5	7
Metribuzin	11	2	16	1	2	5	-	11	2	14	4	8	1	2	1	4
Ethalfluralin	5	-	2	4	4	-	2	-	8	-	4	4	-	-	-	3
Trifluralin	29	28	30	16	9	35	31	13	38	37	19	22	8	5	44	24
Imazaquin	6	13	4	-	-	-	2	22	-	21	2	-	1	-	14	4
Chlorimuron-ethyl	26	5	7	1	3	1	4	11	-	6	5	-	-	1	9	3
Other	11	11	12	7	12	5	15	8	4	26	8	4	15	8	12	9
Tank mixes--																
Acifluorfen + bentazon	3	4	2	2	3	1	5	-	1	13	4	1	1	5	9	3
Metolachlor + metribuzin	3	-	2	6	8	-	2	2	-	1	1	1	-	8	-	3
Alachlor + linuron	-	-	-	2	14	1	8	10	3	-	8	4	6	16	-	5
Alachlor + metribuzin	3	1	5	3	13	5	1	3	-	1	4	9	1	15	-	5
Metribuzin + pendimethalin	3	2	9	2	3	4	-	1	-	3	2	5	-	2	1	2
Imazaquin + pendimethalin	-	7	4	2	-	-	4	4	-	3	2	-	1	-	5	2
Metribuzin + trifluralin	2	2	7	17	6	24	4	6	19	12	14	28	6	9	4	14
Imazaquin + trifluralin	8	9	-	2	-	-	2	1	-	6	-	-	1	-	10	2
Other 2-way mixes	5	15	4	22	21	13	35	27	15	16	16	4	34	19	16	17
3-way mixes	6	5	2	4	6	3	11	12	2	1	5	-	3	8	7	4
								Number								
Acre-treatments	1.7	1.4	1.3	1.3	1.3	1.3	1.6	1.6	1.2	2.1	1.3	1.2	1.2	1.2	1.7	1.4

herbicide-treated soybean acreage. In contrast, Mississippi farmers averaged 2.1 acre-treatments, with some acreage treated 3 or 4 times.

Trifluralin was the most commonly used soybean herbicide treatment in 1986. It was used extensively in all States except Indiana, North Carolina, and Ohio. Trifluralin applied preplant controls many broadleaf and grass weeds.

Metribuzin + trifluralin was the second most important herbicide treatment. The inclusion of metribuzin in the mixture increases the weed control spectrum, especially for cocklebur and velvetleaf.

Pendimethalin (velvetleaf control) and metribuzin applied alone were used extensively in the Southeast and Delta. Tank mixes of alachlor + linuron and alachlor + metribuzin were the dominant treatments in Indiana and Ohio. Two new active ingredients, imazaquin and chlorimuron-ethyl, registered in the spring of 1986 were used extensively in the Southeast and Delta. Imazaquin can be applied preplant incorporated, preemergence, or postemergence. It controls many broadleaf and grass weeds and may be tank-mixed with other herbicides to increase the control spectrum. Chlorimuron-ethyl can only be applied postemergence. It is particularly effective in controlling large cocklebur and sunflower plants. Chlorimuron-ethyl can be tank-mixed with acifluorfen to increase the control spectrum, especially for black nightshade.

Wheat

Herbicides were used on 38 percent of the winter wheat acreage in the surveyed States in 1986 (table 22). Missouri farmers treated only 1 percent of their winter wheat acreage while in Oregon 94 percent was treated. In the Pacific Northwest, winter annual broadleaf weeds and grasses are a problem and must be controlled even during mild portions of the winter. In Montana, winter wheat stands can be thinned by winter kill and invading weeds must be controlled to prevent additional yield loss.

For spring and durum wheat, 86 and 98 percent of acreage, respectively, was treated with herbicides. Because the seedbed is prepared in the spring, it provides a good medium for both crop and weed germination. Weeds must be controlled to reduce competition with the seedling wheat plants.

Table 22--Pesticide use on wheat, 1986 1/

State 1/	Acres treated with: Herbicides	Acres treated with: Insecticides
	Percent	
Winter wheat		
Arkansas	6	nr
California	57	7
Colorado	25	nr
Idaho	65	4
Illinois	4	nr
Indiana	11	2
Kansas	42	nr
Missouri	1	nr
Montana	84	14
Nebraska	36	nr
Ohio	4	nr
Oklahoma	36	9
Oregon	94	7
Texas	19	14
Washington	91	nr
Average	38	5
Spring wheat		
Idaho	77	nr
Minnesota	91	4
Montana	82	44
North Dakota	90	5
South Dakota	73	2
Average	86	12
Durum wheat		
North Dakota	98	13

nr -- none reported.

1/ States surveyed planted 65.3 million acres (91 percent of U.S. total).

Insecticide use in wheat production was most important in Montana. Grasshoppers were a problem and as a result, 44 percent of the spring wheat and 14 percent of the winter wheat acreage were treated. The treatment of strips around the edges of a field are not included in the above percentages.

Herbicides were used on nearly 17 million winter wheat acres with an average of 1.1 applications per acre (table 23). Except in Oregon and Washington, 2,4-D was the most commonly used herbicide and was applied to 37 percent of the treated acreage. It was discovered in 1942 and has been used

Table 23--Selected herbicides used in winter wheat production, 1986 1/

Item	CA	CO	ID	KS	MT	NE	OK	OR	TX	WA	Total
						Thousand					
Acres treated with herbicides	370	835	810	4815	1800	835	2680	910	1575	2040	16670
						Percent					
Active ingredients:											
Single materials--											
2,4-D	60	36	49	44	39	68	36	7	33	10	37
MCPA	23	-	-	3	2	1	4	7	-	-	3
Dicamba	5	4	1	3	1	14	-	2	-	4	3
Triallate	-	-	5	1	3	-	-	-	-	2	1
Chlorsulfuron	-	20	2	22	7	19	57	14	47	38	28
Dicolofop-methyl	2	-	7	-	-	-	-	7	-	3	1
Glyphosate	-	-	-	1	-	-	1	1	11	5	2
Other	5	4	14	4	9	8	-	12	6	13	6
Tank mixes--											
2,4-D + dicamba	-	4	7	18	23	5	-	10	-	10	10
2,4-D + chlorsulfuron	-	-	-	4	9	-	-	2	3	2	3
2,4-D + others	-	24	2	1	5	-	-	7	-	3	3
MCPA + others	9	-	11	1	2	-	-	11	-	7	3
Bromoxynil + chlorsulfuron	-	-	2	-	-	-	-	1	-	6	1
Other 2-way	2	12	11	2	2	-	3	18	-	12	5
3-way mixes	-	-	5	-	-	-	-	23	-	8	3
						Number					
Acre-treatments	1.1	1.0	1.2	1.0	1.0	1.2	1.0	1.2	1.0	1.2	1.1

1/ Detailed data not presented for AR, IL, IN, MO, and OH because of the limited acreage treated with herbicides (table 9).

extensively as a postemergence control of broadleaf weeds in small grain production.

Chlorsulfuron, registered in 1982, was the second most important herbicide used in winter wheat production. It may be applied pre- or postemergence to control many broadleaf weeds and in addition supress competition from Canada thistle, foxtail, wild buckwheat, Russian thistle, kochia, and sunflower.

Herbicides were used on 12.5 million acres of spring wheat and 2.7 million acres of durum in 1986 (table 24). Acre-treatments averaged 1.1 for spring wheat and 1.2 for durum acreage. The most commonly used herbicide was 2,4-D followed by another phenoxy, MCPA.

Regulatory Actions

Following is a summary of Special Reviews being conducted by the Environmental Protection Agency (EPA) for pesticides used in agriculture. The public is informed of the initiation of a Special Review with the publication of the risk analyses, Position Document (PD) 1. EPA presents its proposed regulatory decision in PD 2/3. After a period of public comment and scientific review, a final position document (PD 4) is published delineating EPA's actual regulatory decision.

Special Reviews by EPA

Common Name	Category	Major Use	Possible Risk	Status
Alachlor	Herbicide	Corn, soybeans, peanuts	Carcinogen	PD 4, fall 1987
Aldicarb	Insecticide, nematicide	Peanuts, potatoes, cotton, citrus	Acute toxicity	PD 2/3, spring 1987
Amitrole	Herbicide	Non crop areas	Carcinogen	PD 2/3, fall 1987
Cadmium	Fungicide	Golf courses	Carcinogen, birth defects, fetal death	PD 2/3, summer 1987
Captafol	Fungicide	Apples, citrus, potatoes, tomatoes	Carcinogen	PD 2/3, summer 1987
Carbofuran	Insecticide	Corn, peanuts, sorghum, sunflowers	Wildlife, bald eagles	PD 4, spring 1987
Chlordimeform	Insecticide	Cotton	Carcinogen	PD 4, fall 1987
Cyanazine	Herbicide	Corn, sorghum, cotton	Birth defects	PD 4, summer 1987
Dinocap	Fungicide	Apples	Birth defects	PD 4, fall 1987
Linuron	Herbicide	Corn, fruits, vegetables	Carcinogen	PD 2/3, summer 1987
Triphenltin hydroxide	Fungicide	Potatoes, peanuts, sugar beets	Birth defects	PD 2, summer 1987

Table 24--Selected herbicides used in spring wheat production, 1986

Item	Spring wheat						Durum
	ID	MN	MT	ND	SD	Total	ND
				Thousand			
Acres treated with herbicides	370	2600	2330	5645	1545	12490	2690
Active ingredients:							
Single materials--				Percent			
2,4-D	65	24	41	41	56	40	60
MCPA	-	23	2	24	17	18	16
Bromoxynil	-	18	-	6	-	6	2
Triallate	5	3	3	7	-	5	5
Chlorsulfuron	-	2	9	3	-	3	1
Dicolofop-methyl	14	6	5	3	-	4	4
Other	14	19	9	10	6	11	17
Tank mixes--							
2,4-D + dicamba	8	3	29	7	8	10	-
MCPA + dicamba	-	8	3	1	8	4	2
Other	14	13	9	11	8	11	17
				Number			
Acre-treatments	1.3	1.2	1.1	1.1	1.0	1.1	1.2

POTENTIAL GROUNDWATER CONTAMINATION FROM AGRICULTURAL CHEMICALS: A NATIONAL PERSPECTIVE

Elizabeth G. Nielsen and Linda K. Lee[1/]

Abstract: Evidence is mounting that agricultural pesticide and fertilizer applications are causing groundwater contamination in some parts of the United States. This paper synthesizes national data to identify regions potentially affected by contamination from these sources, and estimates the number of people in these regions who rely on groundwater for their drinking water needs.

Keywords: Groundwater contamination, agricultural chemicals, nitrates, pesticides, drinking water

Over 97 percent of all rural domestic drinking water in the United States comes from underground sources, along with 55 percent of livestock water, and 40 percent of all irrigation water (18).[2/] According to U.S. Census data, over 30 million people obtain their drinking water from private wells (19). Heavy reliance on groundwater is not limited to rural America. In 1980, groundwater served 40 percent of the population using public water supplies--nearly 74 million people (18). Moreover, total groundwater withdrawals grew 158 percent from 1950 to 1980, compared to a 107-percent growth of surface water withdrawals (18).

Little is known about the extent of most groundwater contamination from human activities (4). The question, however, is critical. There are documented and suspected risks to human health from exposure to contaminated groundwater (13). Because of the slow movement of groundwater in many areas as well as the slow degradation rate of many chemicals, contamination can persist for years or centuries. Clean-up costs can be prohibitive. Moreover, the interactions between surface waters and groundwaters can mean that in some areas aquifer contamination may ultimately lead to pollution of streams, lakes, and estuaries.

Although groundwater contamination has many sources, evidence suggests that agriculture's relative contribution may be significant. Incidents of groundwater contamination from agricultural pesticides and/or fertilizers have been documented in many parts of the Nation, including Pennsylvania, Florida, Wisconsin, California, New York, and Iowa (for example, see 15, 9, 10, 16, 17, 26, 3, 25, 11, 8).

This article presents the results of a research effort designed to assess the magnitude of groundwater contamination caused by the agricultural use of fertilizers and pesticides in the 48 contiguous States. Information on the actual and potential magnitude of contamination is a prerequisite to an assessment of the risks of damages to health and property. The costs of these damages represent the benefits of groundwater protection. The policies and programs now being implemented by several States, including Arizona, California, and Wisconsin, and under discussion by other States and the U.S. Environmental Protection Agency (EPA), require a better understanding

1/ The authors are Economist and Section Leader, respectively, with the Externalities Section, Soil and Water Branch, Natural Resource Economics Division, Economic Research Service. This article summarizes a portion of a research effort by Nielsen and Lee which will be fully described and documented in a forthcoming ERS publication entitled "The Magnitude and Costs of Groundwater Contamination from Agricultural Chemicals: A National Perspective." The full report gives additional detail on the analyses and results presented in this paper, and addresses the costs to society from agriculturally contaminated groundwater.

2/ Numbers in parentheses cite references at the end of the article.

of the benefits of groundwater protection. Only when the benefits are well understood can they be compared with the social and agricultural costs of alternative prevention and control measures for the identification of efficient policy options.

Agriculture and Groundwater Quality

The lack of a consistent and comprehensive data base has made it difficult to establish direct relationships between human activities and contamination episodes. This is particularly true with respect to diffuse, or "non-point" sources, which characterize many agricultural activities such as chemical applications. It is clear, however, that several trends over the past 40 years have increased the potential for agriculturally caused groundwater contamination.

The use of inorganic nitrogen fertilizers, a major source of nitrate-nitrogen groundwater contamination, increased 11-fold between 1950 and 1980 (150 percent from 1965 to 1984). A major cause was heavier fertilizer applications, with the per-acre rate doubling between 1965 and 1984 (20, 22, 23). Concurrently, the agricultural use of pesticides has risen sharply, nearly tripling from 1964 to 1984 (24). Most of the increased use has been accounted for by herbicides, which in 1982 constituted 82 percent of all pesticide use on major field and forage crops (21). Acreage reductions resulting from the 1985 Food Security Act have led to reductions in total use of both pesticides and fertilizers.

Other trends have increased the potential for contamination from both diffuse and concentrated "point" sources in some areas. Wastes generated in concentrated livestock, dairy, and poultry operations have stretched the land's waste assimilative capacity and have caused a potential for nitrate contamination, particularly in areas where commercial fertilizers are also applied. An increase in conservation tillage may imply an increase in both pesticide and fertilizer contamination through increased water infiltration and reduced run-off, although the relationships are not well understood and may vary from one area to another. Expansion of irrigated acreages over the years also may have contributed to groundwater contamination. Irrigation can increase the concentration of salts, pesticides, and fertilizers in groundwater recharge, as well as in return flows.

The potential for groundwater contamination, as well as the magnitude, extent, and duration of contamination, depend not only on land uses and agricultural practices, but also on climate, hydrogeological, and other conditions. These include soil characteristics, net aquifer recharge rates, depths to the water table, and characteristics of the unsaturated zone and the aquifer.

The characteristics of a potential pollutant such as water solubility, sorption, and persistence strongly affect its ultimate fate. In addition to increased pesticide and fertilizer use, changes in the types of pesticides applied (i.e., generally less persistent, but less likely to attach to soil particles) may mean a greater likelihood of contamination, particularly when recharge rates are high. The method, timing, and placement of chemical applications, in addition to tillage and irrigation practices, also affect the likelihood that a chemical will move to groundwater. Of course, accidents, leaks, and improper disposal practices can also lead to local contamination.

Clearly, predicting groundwater contamination requires consideration of diverse factors which interplay in the process. The data presented in this article reflect the interaction of agricultural activities with physical vulnerability to pesticides and nitrates to estimate regional groundwater contamination trends.

Approach

Estimates are developed of the areas of potential groundwater contamination from both pesticides and nitrates in the United States. These areas are first defined by actual levels of contaminants in groundwater, where data are available. If such data are not available, potential contamination is defined by combining data on physical vulnerability to contamination with chemical use data. In both cases, the population in areas of potential contamination is assumed to face a greater risk from agricultural chemicals in groundwater than people in other regions. As

the costs associated with these risks largely depend upon the population potentially exposed, the numbers and distributions of people using groundwater in areas of potential contamination are also projected.

The estimate of potentially contaminated areas is based upon a synthesis of several data sources. While each of these sources has limitations, which in aggregate decrease the sensitivity of localized analysis, the sources represent the best available data and depict regional trends. The full paper contains complete descriptions of all of the data sources used in the analysis (14).

Potential Pesticide Contamination

Because there is no national data base on pesticide levels in groundwater, a method was developed to simulate agriculturally caused pesticide contamination, or the potential for it. This method involved the synthesis of two data sources. The first is the U.S. county-level pesticide DRASTIC assessment. DRASTIC is an acronym for an index that rates an area's relative vulnerability to groundwater contamination, based upon its hydrogeologic characteristics (D = depth to the water table; R = net recharge; A = aquifer media; S = soil media; T = topography; I = impact of the vadose zone; and C = hydraulic conductivity) (1, 2). A version of the DRASTIC index developed specifically for pesticides was used for this assessment.

The second data source is a county-level pesticide use data base developed by an independent research organization, Resources for the Future (RFF) from surveys conducted between 1977 and 1982 (7). Applications of 184 pesticides on 76 crops are represented in the file. To focus on potential problem pesticides, we limited our analysis to 38 chemicals in the RFF data base which were recommended for inclusion in the EPA national survey of pesticides in well water (5). These pesticides, primarily herbicides, represent 60 percent of all agricultural pesticide applications accounted for in the RFF file.

We translated the total county-level use estimates into average per-acre applications, using acres of cropland from the 1982 Agricultural Census, and we apportioned them into high, medium, and low categories. Similarly, the pesticide DRASTIC scores were apportioned into these three categories. Using the hypothesis that hydrogeologic and pesticide use factors provide more information on the potential for contamination than do either of the indices alone, we calculated three combinations of the high and medium categories for the two variables, which are depicted in figure 1 as areas of potential contamination from pesticide use.

Three hundred and sixty-one counties fall into both the high DRASTIC and high pesticide use categories. The remaining areas highlighted by figure 1 have either a high DRASTIC score and medium pesticide applications or the reverse combination. In total, 1,128 counties are represented in figure 1, or roughly one-third of the counties in the conterminous States.

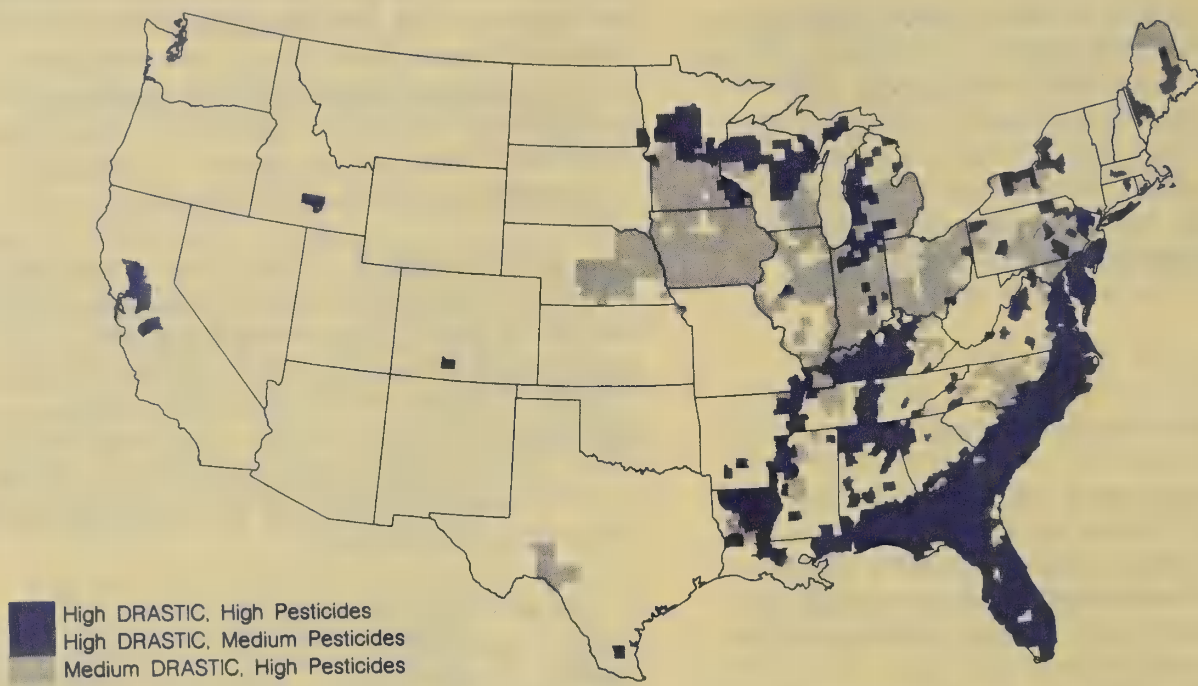
In general, the southern Coastal Plain (including Florida), the central Atlantic region, the Mississippi Delta, the midwestern Corn Belt, western Kentucky, and the Central Valleys of California are the major regions with predicted pesticide contamination potential. Other smaller areas in the Northeast, Texas, and Idaho also have potential contamination.

The regions depicted in figure 1 as having potential groundwater contamination from pesticides correspond with production of pesticide-intensive crops such as corn and soybeans. Tobacco, cotton, rice, and peanut production in the Southeast also show high pesticide use. Fruit and vegetable production is represented by high use in Florida, California, and portions of the Northeast and Lake States.

Although figure 1 is not based on actual levels of contaminants in groundwater, the data generally correspond to verified incidents of groundwater contamination from normal agricultural pesticide use as shown, by State, in table 25 (6). Because this table does not represent a random sample, and because sampling incidence, frequency, and patterns vary dramatically from State to State, the data might be considered the lower bound on actual instances of groundwater contamination. The data also reflect the intensity with which monitoring programs in

Figure 1

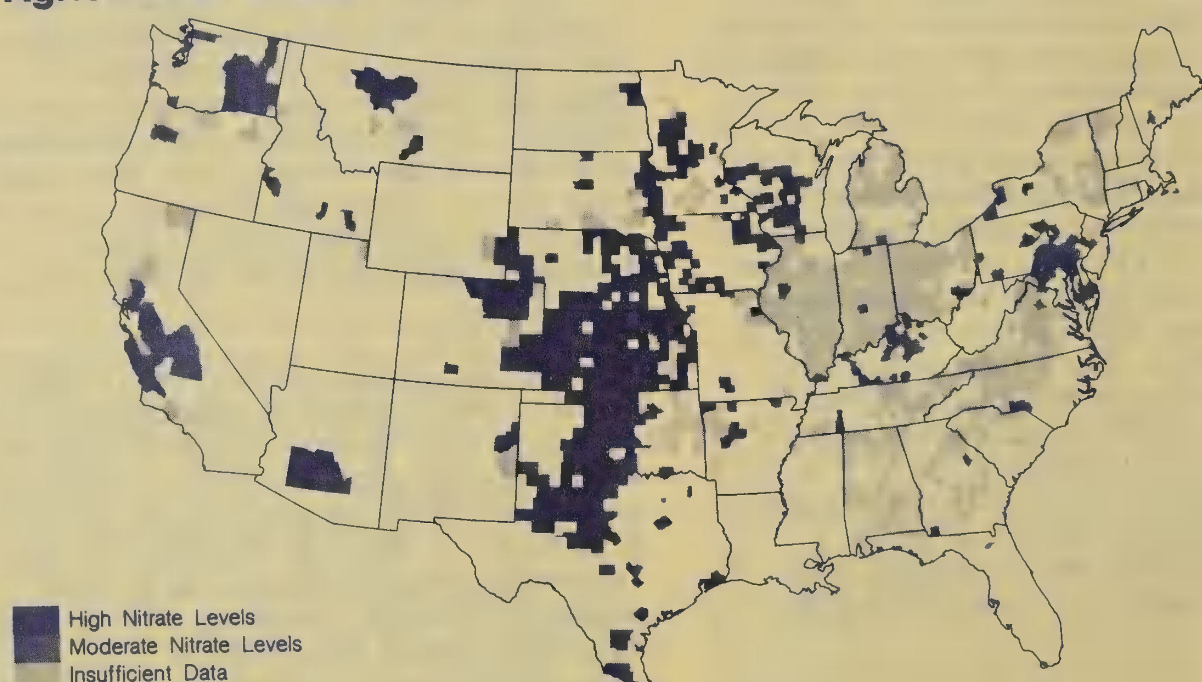
Potential Groundwater Contamination from Pesticide Use



Source: (14)

Figure 2

Nitrate-Nitrogen Distribution in Groundwater in Agricultural Areas



Source: (14)

Table 25--Number of pesticides found in groundwater as a result of agricultural practices, by State 1/

State	Number of pesticides
Arizona	3
Arkansas	1
California	6
Connecticut	1
Florida	3
Georgia	1
Hawaii	2
Iowa	6
Maine	1
Maryland	5
Massachusetts	2
Nebraska	2
New Jersey	1
New York	6
North Carolina	1
Oregon	1
Pennsylvania	3
Rhode Island	2
South Carolina	2
Texas	1
Virginia	1
Washington	2
Wisconsin	3

1/ Source: (6)

each particular State have tested for pesticides.

Potential Nitrate Contamination

Estimating areas of potential contamination from agricultural fertilizer use involved the synthesis of three data bases. The primary source was data from the U.S. Geological Survey (USGS) on nitrate-nitrogen levels in groundwater (12). Because of regional gaps in the USGS file, a proxy for contamination was developed from DRASTIC and ERS fertilizer use data.

Multiple criteria were used to exclude nonagricultural areas from the USGS data file to avoid attributing nitrate levels from nonagricultural sources such as septic tanks to nitrogen applications. Accordingly, about one-fourth, or 753 counties, were excluded. Also, counties with fewer than five wells sampled (661 counties) were omitted from the analysis on the basis of insufficient information. The 1,663 counties remaining in the data base were analyzed with respect to nitrate levels in groundwater.

Figure 2 maps the results of this analysis. Areas in which 25 percent or more of sampled wells exceeded 3 milligrams per liter (mg/l) of nitrate-nitrogen are postulated to indicate influences from human activities (12); 474 counties satisfy these conditions. Of these 474 counties, 87 had at least one-fourth of sampled wells exceeding the National Interim Primary Drinking Water Regulations for nitrates, 10 mg/1. These are shown separately in figure 2, as are the 661 counties with insufficient data. Nonshaded areas include both those counties which were excluded as being nonagricultural, and agricultural counties in which fewer than 25 percent of sampled wells exceeded 3 mg/l of nitrate-nitrogen.

According to these data, nitrate-nitrogen contamination of groundwater appears to be concentrated in the central Great Plains, the Palouse and western Washington State, portions of Montana, southwest Arizona, the irrigated fruit, vegetable, and cotton-growing areas of California, portions of the upper Corn Belt, southeast Pennsylvania, Maryland, and Delaware. In many cases, the areas highlighted in figure 2 represent a combination of fertilizer applications and irrigation, particularly in California, the Palouse area in Washington, northern Texas, and portions of Kansas and Oklahoma. However, not all areas with this combination appear as problems in figure 2; Florida is an important example.

Because of the large number of counties with insufficient data, a contamination proxy was developed to supplement the USGS data. Similar to the pesticide pollution potential analysis described earlier, the regular DRASTIC index county ratings were combined with estimates of nitrogen fertilizer applications to project areas of potential nitrate contamination. Counties with both high DRASTIC scores and high fertilizer applications, as well as those with a medium score on one variable and a high score on the other, were identified as areas of potential contamination and were used to supplement the USGS data in those areas with insufficient data. This resulted in the addition of 149 counties identified as potentially contaminated, which are located primarily in the eastern Corn Belt. Combining these with the 474 counties from the USGS analysis gave a total of 623 counties with potential groundwater contamination from fertilizer use.

Areas of Potential Contamination

Together, areas of potential contamination from pesticide and fertilizer use account for 1,437 counties, or about 46 percent of the counties in the conterminous States. Figure 3 shows evidence of regional trends. Counties with only potential pesticide contamination total 814, and are located largely along the Eastern Seaboard, the Gulf Coast, and the upper Midwest. Counties with only potential nitrate contamination total 309, and occur principally in the Great Plains and portions of the Northwest and Southwest. Only 314 counties, less than one-fourth of those identified to have potential contamination from agricultural chemicals, exhibit both high pesticide and nitrate contamination potential. These are located chiefly within the Corn Belt, the Lake States, and the Northeast.

These 1,437 counties with pesticide or nitrate contamination are cropped intensively, with 33 percent of all land area in crops compared with 16 percent nationwide. Over 70 percent of the crop acreage in the sample is devoted to corn, wheat, and soybeans. Though strongly agricultural, these counties are heavily populated, with 27 percent of the land but 47 percent of the population.

The limitations of the data bases used to develop the projections reflected in figures 1-3 prohibit analysis at the subregional level. County-level averaging, measurement errors, or data extrapolations that took place in the development of particular data sources can cause distortions at that level. These are described, by source, in the full paper (14). Regional trends can be analyzed from the data depicted in figures 1-3. These regional patterns have implications for the distribution of the population potentially affected by agricultural groundwater contamination and the costs that might result.

Population Potentially Affected

People who live where the contamination potential from agriculture is high and consume mostly groundwater most likely will incur the highest costs. These costs include monitoring and detection activities, adverse health effects, the installation of water filters, or the use of bottled water.

To estimate the potentially affected population, we used data from the 1980 Census of Population and Housing on drinking water sources for the 1,437 potentially contaminated counties. The Census gives data on people using water from private wells and from public supplies. Statewide averages of the percentages of all public water supplies that use groundwater (18) were used to estimate the population in each county using public groundwater supplies.

Figure 4 depicts the distribution of the population relying on groundwater from both individual wells and public sources in the identified areas of potential contamination from nitrates and pesticides. The areas with the most people relying on groundwater are scattered throughout the South, Northeast, Midwest, and portions of the West.

Over 19 million people in these counties obtain their drinking water from private wells (table 26). Over 65 percent of these people live in areas where only potential pesticide contamination is indicated, while less than 10 percent live in areas with only potential nitrates. The remainder reside in areas with a potential for both pesticides and nitrates. As with private wells, the majority of people using public groundwater supplies (68 percent) reside in areas with only potential pesticide contamination (table 26). The remainder are divided nearly equally into areas of only potential nitrate contamination and both pesticide and nitrate contamination. Table 27 breaks down these population data by State.

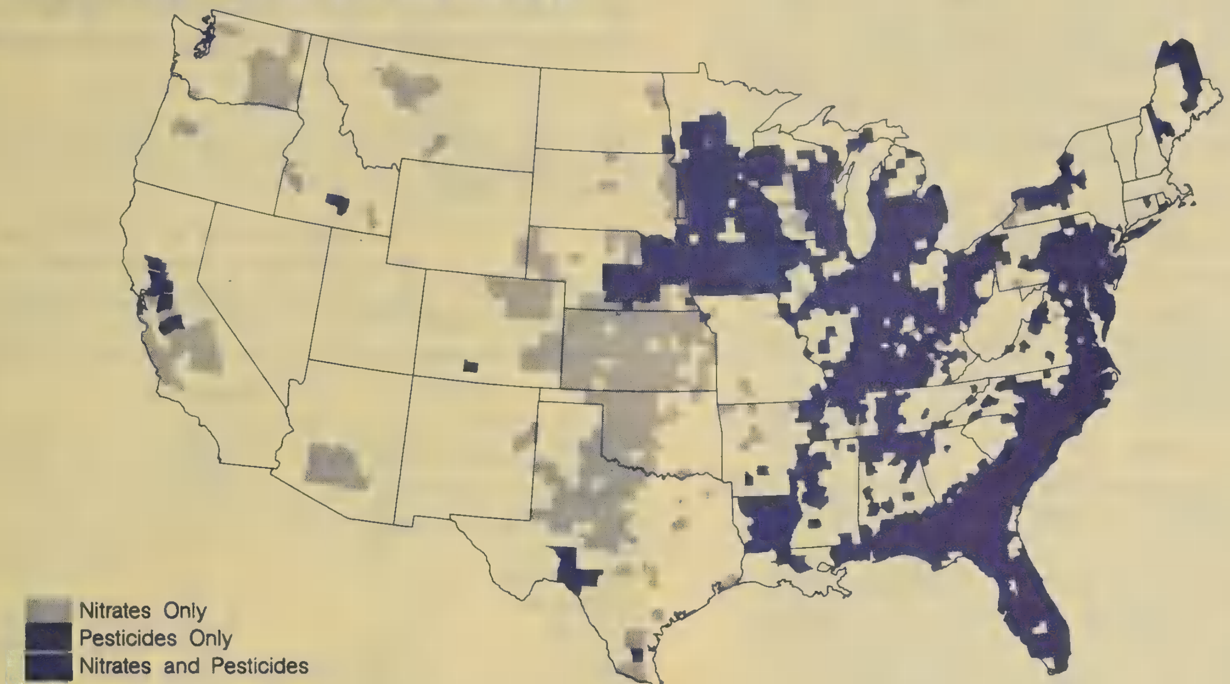
Summary and Implications

Agricultural chemical contamination of groundwater could affect a significant component of the U.S. population, 53.8 million people. This occurs because of the density of population in the areas affected and their heavy reliance on groundwater and private wells. Despite the large population potentially affected, data indicate that groundwater contamination from agricultural chemicals is not national in scope. Rather, areas of potential contamination appear to be regional, which suggests that targeting is needed for any prevention strategy.

Based upon our analysis, pesticides and nitrates in groundwater do not necessarily occur together. In fact, in three-fourths of

Figure 3

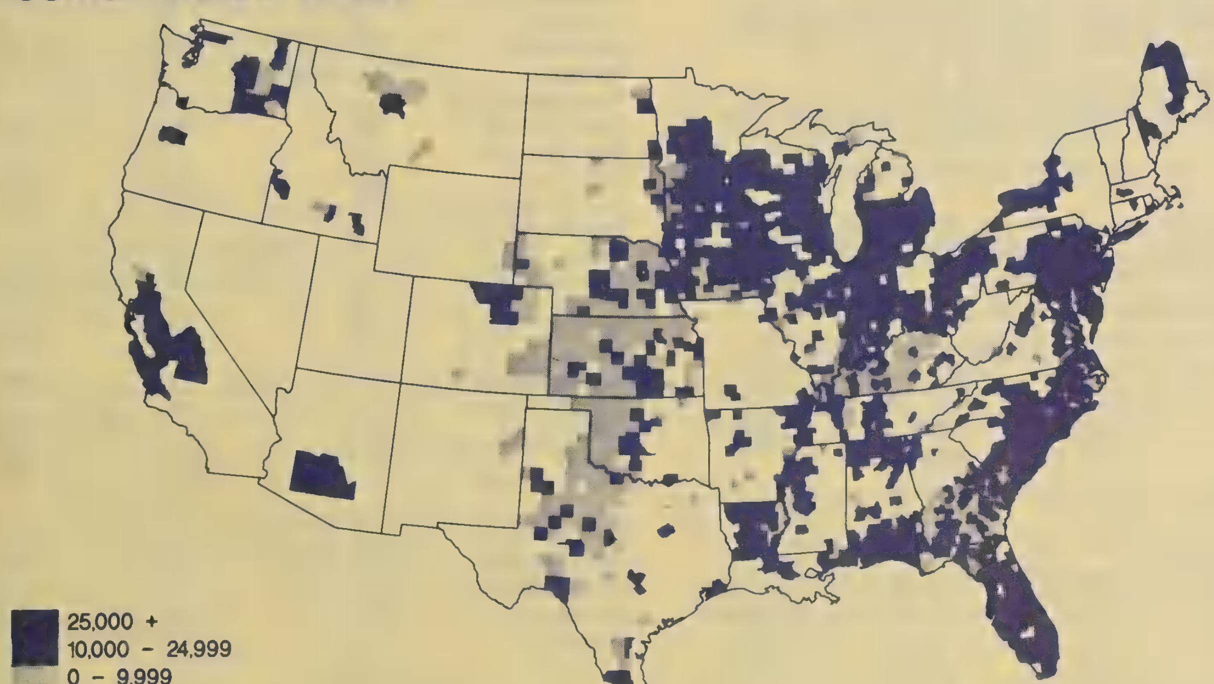
Areas of Potential Groundwater Contamination from Agricultural Chemicals



Source: (14)

Figure 4

Population Relying on Groundwater in Potentially Contaminated Areas



Source: (14)

the 1,437 potentially contaminated counties, pesticide and nitrate problems are not necessarily predicted simultaneously. The presence of nitrates may suggest pesticide problems and vice versa, but other factors may intervene to prevent the presence of both in groundwater. This suggests that different strategies may be appropriate for pesticides than for nitrates in groundwater.

Over one-third of all of the people estimated to rely on groundwater for their drinking water use private wells. These people may have a higher risk of drinking water containing agricultural chemicals than those using public supplies since their wells are normally shallower and more susceptible to contamination, and are less likely to be monitored for contaminants. Farmers' private wells are likely to be directly affected when agricultural chemicals reach groundwater. Thus, there are strong incentives for farmers to reduce or minimize activities that pollute. Unfortunately, there is little advice to give farmers about the impact of agricultural practices, such as conservation tillage, on groundwater quality. While farmer education programs are needed, their success will in part depend on well-documented research, much of which is just being initiated.

While the findings in this report indicate a significant potential for groundwater contamination from agricultural chemicals, the data do not determine the magnitude of the costs from such contamination. An analysis of one component of these costs--those of monitoring and detection--is reported in a forthcoming research report, along with a description and discussion of remedial costs. Work is in progress to estimate the costs associated with agricultural chemical groundwater contamination and alternative prevention and control strategies.

Table 26--People served by public and private groundwater supplies in potentially contaminated areas, by type of contamination

Type of contamination	People served		
	Private wells 1/	Public wells 2/	Total
	Thousands		
Nitrates only	1,674	5,401	7,075
Pesticides only	12,592	23,450	36,042
Nitrates and pesticides	5,075	5,641	10,716
Total	19,341	34,492	53,833

1/ Source: (19). 2/ Estimated from (18) and (19).

Table 27--People served by private and public groundwater supplies in potentially contaminated areas, by State

State	Persons served by groundwater in potentially contaminated areas		
	Private1/	Public2/	Total3/
	Thousands		
Alabama	463	648	1,111
Arizona	25	944	969
Arkansas	126	201	327
California	408	1,769	2,177
Colorado	55	110	165
Connecticut	59	9	68
Delaware	131	227	358
Florida	1,141	6,612	7,753
Georgia	598	507	1,105
Idaho	80	225	305
Illinois	672	2,798	3,470
Indiana	1,404	2,097	3,501
Iowa	567	1,613	2,180
Kansas	237	905	1,142
Kentucky	402	251	653
Louisiana	198	688	886
Maine	125	47	172
Maryland	664	307	971
Massachusetts	19	29	48
Michigan	2,031	1,276	3,307
Minnesota	781	1,395	2,176
Mississippi	147	595	742
Missouri	76	93	169
Montana	14	30	44
Nebraska	217	764	981
Nevada	-	-	-
New Hampshire	-	-	-
New Jersey	582	1,240	1,822
New Mexico	2	7	9
New York	664	1,230	1,894
North Carolina	1,390	300	1,690
North Dakota	7	42	49
Ohio	1,434	2,009	3,443
Oklahoma	122	140	262
Oregon	35	15	50
Pennsylvania	1,620	1,273	2,893
Rhode Island	24	10	34
South Carolina	591	311	902
South Dakota	30	111	141
Tennessee	222	717	939
Texas	163	874	1,037
Utah	-	-	-
Vermont	-	-	-
Virginia	513	213	726
Washington	106	310	416
West Virginia	35	32	67
Wisconsin	1,093	1,441	2,534
Wyoming	5	3	8
Total	19,341	34,492	53,833

1/ Source: (19). 2/ Estimated from (18) and (19). 3/ Totals may not add due to rounding.

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FARM MACHINERY

Demand

Farm equipment expenditures fell to an estimated $4.5 billion in 1986, and will likely stablize to between $4.1 and $4.7 billion in 1987. Farm debt relative to farm asset values, interest rates, cash income, and tax law changes are among the factors affecting total farm machinery purchases. The debt/asset ratio indicates a worsened equity position in agriculture. The ratio increased an estimated 6 percent in 1986 but is expected to improve in 1987 (table 28). Interest rates did not encourage machinery purchases in 1986, as the real PCA (Production Credit Association) interest rate increased from year-earlier levels. In addition, the 1986 tax law will be in full effect in 1987, increasing after-tax farm machinery investment costs an estimated 11 percent. On the positive side, net cash income is forecast to increase in 1987 after remaining flat in 1985 and 1986.

Falling Asset Values

The continuing decline in farm machinery purchases is due, in part, to the worsening financial condition of many farmers as indicated by the rising debt/asset ratio for the farm sector. The debt/asset ratio rose as farm asset values fell faster than the level of farm debt. Farm real estate values are estimated to have fallen 9 percent in 1986 following consecutive declines in the previous 5 years. From 1940 to 1970, farm real estate values remained relatively stable. The fall in farm real estate values during the 1980's has erased all of the increase in inflation-adjusted real estate values attained during the 1970's. The largest valued component of farm real estate is land. The decline in farm land values follows from the expected lower net returns to land and historically high real interest rates. The Food Security Act of 1985 reduces commodity loan rates and target prices through 1990 which may reinforce farmers' expectation of lower returns to land.

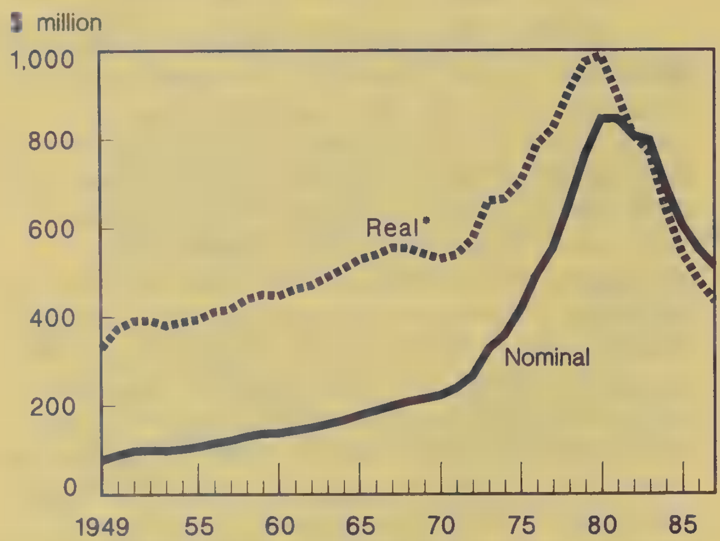
Table 28--Trends in U.S. farm machinery capital expenditures and financial factors affecting demand for farm machinery

Item	1981	1982	1983	1984	1985	Forecast 1986	Forecast 1987
					Billion dollars		
Capital expenditures:							
Tractors	3.74	2.88	2.75	2.53	2.11	1.3	1.1-1.4
Farm machinery	6.48	5.10	4.82	4.75	3.77	3.2	3.0-3.3
Total	10.2	7.98	7.57	7.25	5.88	4.5	4.1-4.7
Tractor and machinery repairs	3.8	3.9	4.0	4.0	4.0	3.9	4.4
Factors affecting demand:							
Interest expenses	19.9	21.8	21.4	21.1	18.7	16	15
Total production expenses	139	141	139	142	136	130	120
Outstanding farm debt 1/	202	217	216	212	205	190	170
Farm real estate assets 1/	840	809	798	694	607	550	510
Farm nonreal estate assets 1/	264	273	264	262	212	200	200
Agricultural exports 2/	43.8	39.1	34.8	38.0	31.2	26	na
Net farm income	26.9	22.7	13.0	32.7	30.5	25	31
Net cash income	32.8	36.8	37.1	39.3	44.0	44	48
					Percent		
Real prime rate 3/	8.50	8.73	7.57	7.88	6.73	6.2	4.9
Real PCA interest rate 3/ 4/	4.76	8.18	8.15	8.37	9.10	9.3	8.6
Nominal farm machinery and equipment loan rate 5/	17.9	17.1	14.3	14.6	13.7	6/ 13	na
Debt-asset ratio 7/	18.2	20.1	20.4	22.2	23.6	25	24

na = not available

1/ Calculated using nominal dollar balance sheet data, including farm households for December 31 of each year. 2/ Fiscal year. 3/ Deflated using 1982 GNP Deflator. 4/ Production Credit Association . 5/ Average annual interest rate. From the quarterly sample survey of commercial banks: Agricultural Finance Databook, Board of Governors of the Federal Reserve System. 6/ Average of the first and second quarters of 1986. 7/ Outstanding farm debt (including households) divided by the sum of farm real and nonreal estate asset values.

Farm Real Estate Values



* Base 1982.

Cash Income

A positive, though in recent years small, influence on farm machinery demand stems from an increase in cash income. In 1987, net cash income is expected to continue to rise, due to lower production costs and greater direct Government program payments. Net cash income likely remained near year-earlier levels for 1986 and is expected to rise 9 percent in 1987. When accounting for inflation, the purchasing power of cash income was probably slightly lower in 1986 but may be higher in 1987 than in 1985. This income flow could positively affect farm equipment purchases by providing farmers with liquidity. However, since 1983 farmers have used this increase in cash flow to retire debt, not to purchase more equipment.

Planted Acreage

Acreage reduction programs, paid land diversion, and the long-term Conservation Reserve Program (CRP) diverted an estimated 49 million acres from production in 1986, 18 million acres more than in 1985. Heavy participation and increased acreage reduction requirements for 1987 programs, along with the voluntary paid land diversion and CRP are expected to increase idled acreage in 1987. Less use of farm machinery reduces wear on the implements, which implies less need for machinery replacement.

Finance

Nominal non-real estate operating loan rates indicate lower interest rates in 1986 offering some relief in farmers' cost of borrowing. However, these are nominal rates and do not account for changes in the purchasing power of repaid dollars. The real PCA rates remained near the 1985 record level, indicating no significant downturn in real borrowing costs in 1986.

New Tax Law

Estimates indicate an increase of 11 percent in after tax farm machinery investment costs due to the Tax Reform Act of 1986. The new tax law will eliminate the investment tax credit, lower tax rates, and spread depreciation recovery over a longer period of time.

Unit Sales

Preliminary estimates of new farm implement unit sales for 1986 indicate a continuation of the decline that began in 1980 (table 29). There appears to be little change in the downward trend in sales of 40–99 horsepower (hp) two-wheel drive, over 100 hp two-wheel drive, and four-wheel drive tractors, with the four-wheel drive unit continuing to lose the most ground.

Dealer incentive programs offered on self-propelled combines in third- quarter 1986 appear to have turned around what would have been a precipitous decline in combine and corn head sales. However, self-propelled combine unit sales still fell an estimated 11 percent in 1986. The fall in unit sales of mower conditioners is estimated to be less significant than previous years, whereas sales of baler and forage harvestors have continued their marked decline.

Tractor Down-Sizing

In 1985, both the average size of new over-40 hp farm wheel tractors and total new power takeoff (PTO) hp added to the sector fell, continuing a trend that began approximately 5 years ago (table 30). The average size of new over-40 hp farm wheel

Table 29--Domestic farm machinery unit purchases

Machinery category	Annual average 1978-80	Annual average 1981-83	1984	1985	Preliminary 1986	Change 1985-86
			Units			Percent
Tractors:						
Two-wheel drive--						
40-99 hp	62,818	43,421	38,260	37,847	30,600	-19
Over-100 hp	59,543	33,528	24,505	17,700	14,500	-18
Four-wheel drive	10,276	7,188	3,975	2,912	2,100	-27
Grain and forage harvesting equipment:						
Self-propelled combines	29,834	18,594	11,437	8,411	7,500	-11
Corn heads	20,338	10,608	6,419	5,016	5,100	2
Forage harvesters 1/	11,145	5,611	3,538	2,460	2,100	-15
Haying equipment:						
Balers 2/	17,501	10,528	8,315	7,038	5,700	-19
Mower conditioners	23,392	15,586	13,057	11,243	11,000	-2

1/ Shear bar type. 2/ Producing bales up to 200 pounds.

Source: Historical data are from the Farm and Industrial Equipment Institute (FIEI). Unit sales for 1986 are ERS forecasts.

Table 30--Power estimates for farm purchases of new over-40 horsepower wheel tractors

Year	Total PTO horsepower 1/ Million	Total PTO horsepower 1/ Percent change	Average PTO horsepower Per unit	Average PTO horsepower Percent change
1977	13.71		104.7	
1978	15.11	10	108.3	3.0
1979	15.30	1	110.1	2.0
1980	13.22	-14	110.8	0.6
1981	11.51	-13	110.8	0
1982	8.37	-27	108.3	-2.0
1983	7.68	-8	107.6	-0.6
1984	6.94	-10	103.9	-3.0
1985	5.64	-19	96.5	-7.0
Projected 1986	5.41	-4	92.6	-4.0

1/ PTO refers to power takeoff. Percent rounded to the nearest whole number.

tractors purchased in 1985 declined 7 percent from 1984's average of 104 hp, while total new PTO horsepower added to the agricultural sector fell 19 percent to 5.64 million. In 1986, average size and total PTO horsepower added to the sector were forecast to decline 4 percent from 1985 levels.

Inventories

Inventories of mid-size (40-99 hp) and large-size (over 100 hp) two-wheel drive and four-wheel drive tractors, as well as self-propelled combines, continued to decline in September. Specifically, manufacturers were able to reduce inventories in all subcategories of over-40 hp farm wheel tractors and self-propelled combines, with the exception of the 90-99 hp two-wheel drive subcategory where inventories rose to 42 percent of last year's level. Manufacturers saw September inventories of farm tractors decline as little as 1 percent for 70-79 hp two-wheel drive tractors and as much as 40 percent for each of the three subcategories of four-wheel drive tractors. Reductions in self-propelled combine inventories ranged from 6 to 54 percent.

Despite manufacturers' success in reducing the absolute levels of farm tractor and self-propelled combine supplies, in several instances unit sales rates are declining faster than inventories. An inventory-to-purchase ratio (IPR) is a good barometer for determining how well the industry is able to align production with demand. The IPR represents the current month's inventory of an item relative to its sales during the previous 12 months. In more favorable times manufacturers sought to keep, on average, a 6-month supply of machinery relative to sales.

During the early 1970's, a period of robust expansion in agriculture, total new PTO hp

added to farming peaked at 15.34 million (in 1973) and averaged 14.7 million hp annually during 1973–81. However, as expansion in the agricultural sector slowed, or in some cases reversed, the need to augment the sector's tractor power requirements diminished. Between 1982 and 1985, new horsepower added to the sector averaged 7.2 million per year.

September IPR's for over-40 hp farm tractors and self-propelled combines indicate a mixed pattern in terms of manufacturers' ability to better peg supply with demand. IPR's for over-100 hp two-wheel drive and four-wheel drive tractors and self-propelled combines were down 3, 33, and 30 percent, respectively (table 31). Four-wheel drive manufacturers have successfully reduced the IPR for every subcategory of four-wheel drive tractor relative to last year. Undoubtedly, the financial troubles of two manufacturers of four-wheel drive tractors during the past year have led to lower production and inventories.

While inventory reduction efforts for large two-wheel drive tractors were successful, selected subcategories within this group continued to pose problems. Specifically, IPR's for 100–119 hp and 120–129 hp two-wheel drive tractors were up 58 and 36 percent, respectively, from September 1985 (table 31). Available data indicate that drops of 13 and 20 percent in absolute inventories, respectively, for these tractor categories in September were not sufficient to offset drops of 44 and 41 percent in unit sales during the previous 12 months.

With the sluggish farm economy, unit sales of 40–99 hp two-wheel drive tractors have plunged much like the recent pattern for large tractors. As a result, IPR's for these smaller tractors increased significantly as inventories grew and purchase rates fell. On average, inventories for each subcategory of mid-size tractor were up 14 percent from September 1985. The IPR for the 90–99 hp mid-size farm tractors was the largest in the industry. Inventories of these machines (first introduced in 1979) represent a 21-month supply given their present rate of sales.

From an historical perspective, additional industrywide cuts in prices and production will be required to reduce inventories relative to sales. Comparing the September 1986 IPR's for farm tractors and self-propelled combines

Table 31--September inventories of over-40 hp farm wheel tractors and self-propelled combines, by size

Machinery category	1979-84	1985	1986	Change 1985-86	Change 1979-86
	Months 1/			Percent	
Tractors:					
Mid-size 2WD--					
40-99	7.8	7.2	8.5	18	9
50-59	8.3	9.1	9.3	2	12
60-69	9.2	9.7	9.6	-1	4
70-79	9.3	8.4	9.3	11	0
80-89	7.9	8.5	10.2	20	29
90-99	8.6	18.5	21.0	14	144
Total	8.4	8.6	9.4	9	12
Large-size 2WD--					
100-119	9.9	10.9	17.2	58	74
120-129	14.8	12.2	16.6	36	12
130-139	8.9	12.1	9.5	-21	7
140-149	12.5	15.6	12.6	-19	1
160-179	12.9	13.8	12.1	-12	-6
180-250	10.1	14.0	12.7	-9	26
Total	10.5	13.4	13.0	-3	24
Four-wheel drive--					
170-199	10.1	18.5	13.0	-30	29
200-249	8.2	17.5	12.0	-31	46
250-375	9.7	12.8	9.0	-30	-7
Total	9.1	16.9	11.4	-33	25
Self-propelled combines:					
Total	8.2	11.0	7.7	-30	-6

1/ Months of inventory are derived by dividing current inventory by average monthly sales for the previous 12 months.

with the September 1979–84 average reveals that only self-propelled combines are beginning to reach more manageable levels. For most over-40 hp farm tractor subcategories, manufacturers are not having as much success in lowering IPR's. The September 1986 IPR's for over-40 hp farm tractors, on average, were up significantly relative to September 1979–84. Considering that the 1979–84 period was characterized by sharply declining unit sales rates and growing inventories, inventory reduction efforts may have to continue for the next few years.

Foreign Trade

The U.S. farm machinery trade situation continued to deteriorate during of 1986 as the United States posted a $114-million farm machinery trade deficit for the first 9 months

Table 32--Farm machinery trade situation 1/

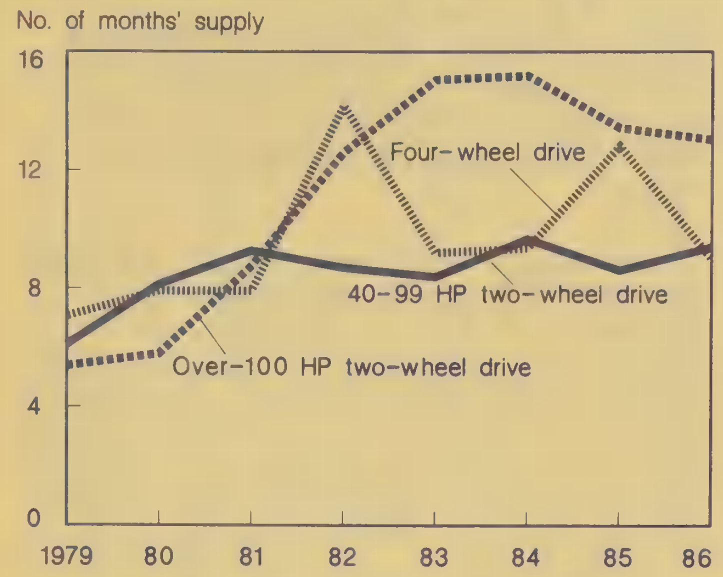
Trade, area	January-September 1985	January-September 1986	Change 1985-86
	Million dollars		Percent
Exports to:			
Africa	71.7	54.4	-24
Australia	101.2	40.1	-60
Canada	611.5	518.5	-15
Central America 2/	23.7	28.9	22
Eastern Europe	28.4	23.0	-19
Far East	32.9	39.7	21
Mexico	182.1	65.0	-64
Middle East	18.8	12.5	-34
Near East	9.4	6.5	-31
Oceania	2.8	2.8	0
Saudi Arabia	78.4	42.7	-46
South America	73.6	95.3	30
Western Europe	187.3	227.7	22
Total	1421.8	1157.1	-19
Imports from:			
Africa	0.6	0.8	33
Canada	321.9	273.6	-15
Central America 2/	6.1	5.7	-7
Eastern Europe	25.1	15.5	-38
Far East 3/	8.4	11.8	40
Italy	102.0	91.9	-10
Japan	262.7	329.2	25
Middle East	5.0	5.6	12
Near East	0.4	0.2	-50
Oceania	12.1	11.5	-5
South America	9.9	8.9	-10
United Kingdom	160.6	185.6	16
West Germany	171.0	205.4	20
Western Europe 4/	120.3	125.3	4
Total	1206.1	1271.0	5
Trade balance 5/	215.7	-113.9	-153

1/ Includes finished machinery items, nonassembled machinery, and parts. 2/ Includes Caribbean countries and excludes Mexico. 3/ Excludes Japan. 4/ Excludes Italy, the United Kingdom, and West Germany. 5/ Trade balance is slightly overstated due to rounding of country export and import totals.

Source: U.S. Department of Commerce. Trade Development, Office of Special Industrial Machinery.

of the year (table 32). Sixty-one percent of the major importers of U.S.-made farm machinery imported less machinery than a year earlier. Weak foreign economies, foreign trade barriers, the cessation of agricultural modernization programs, and movement of U.S. production to overseas plants have contributed to the collapse of the U.S. farm machinery export base. For the first 9 months of 1986, the value of U.S. farm machinery exports fell 19 percent from a year earlier to roughly $1.2 billion. Underlying this decline was a 21- and 17-percent drop in the value of

September Inventories of Farm Wheel Tractors



U.S. Farm Machinery Trade Situation, 1986

wheel tractor and parts and of harvesting machinery exports. These two "big ticket" categories account for nearly 70 percent of the total value of U.S. farm machinery exports.

While the U.S. farm machinery export market continues to shrink, imports of farm machinery are claiming a larger share of the domestic market. This, in part, stems from the shift to tractor production overseas. Department of Commerce statistics indicate that imports accounted for almost 25 percent of the net domestic supply in 1985. For 1986, the relative importance of imports to the net domestic supply probably surpassed the previous year's record.

Through the first 9 months of 1986, the value of imports edged up 5 percent from a

year earlier to $1.3 billion. As in the past several quarters, imports from Japan (largely under-40 hp wheel tractors) accounted for over one-fourth of the total value of farm machinery imports. Imports from West Germany, Italy, the United Kingdom and the rest of Western Europe accounted for 48 percent.

The foreign trade sector of the U.S. farm machinery industry will continue to be affected by the transfer of additional domestic tractor production capacity abroad and by declining export markets. The transfer of wheel tractor production to Western Europe and Japan is but one dimension in the overall restructuring of the domestic farm machinery industry. Likewise, declining export markets for domestically produced farm machinery, especially Canada and Australia, are creating long-term changes in the industry's structure, and as a result, the United States may continue to be a net importer of farm machinery.

ENERGY

U.S. farmers can expect energy prices to remain unchanged or even decline slightly in early 1987, following a 20-percent decline in 1986. Supplies of petroleum and energy products will remain abundant through the 1987 spring planting season. Soft energy prices, coupled with further farm program cuts in planted acres, will likely lead to a $320-million reduction in fuel expenditures during 1987 as compared to 1986. This would boost cumulative reductions in fuel expenditures since 1984 to $2.3 billion. U.S. refiners are forecast to pay close to $16 per barrel for crude oil, a slight upturn from 1986. However, acquisition costs could vary sharply from this forecast depending upon OPEC's ability to adhere to recently agreed upon production cuts and the rate at which current high levels of world oil stocks are drawn down.

Petroleum Consumption

World petroleum consumption grew about 2.5 percent to well over 60 million barrels per day in 1986, encouraged by plummeting crude oil prices, lagged price drops of substitutes, and modest economic growth. In the United States, which accounts for one-quarter of the world total, consumption grew nearly 3 percent, mirroring world economic trends. In Japan and Western Europe, which account for another 25 percent of world use, consumption also increased 2.5 percent. Because oil is traded in dollars, strengthening currencies in many countries further reduced the cost of imported oil, thus boosting imports and consumption.

Positive growth trends in petroleum product demand were not distributed evenly among major consuming countries. Growth in gasoline demand was strongest in the United States and West Germany where gasoline excise taxes remained low, permitting low crude oil prices to be passed on to consumers. In the rest of Europe and Japan where gasoline prices are generally high due to high taxes, the drop in crude prices induced a relatively small drop in retail prices and a weak demand response.

Growth in distillate fuel demand, which consists of diesel fuel and heating fuel, was strongest in West Germany, where consumers took advantage of the unusual decline in prices and stocked up on heating oil in the spring of 1986. Demand also increased, although more moderately, in the United States and other industrial countries. Growth in demand for residual fuel oil, which includes heavy oils used for electric power generation and commercial space heating, was largely a U.S. phenomenon where utilities are more willing to switch among fuel sources.

Crude Oil Production

OPEC increased crude oil production to an average of about 19.0 million barrels per day in 1986, more than 2.0 million barrels per day over the 1985 level. Saudi Arabia and Kuwait, attempting to regain market shares, accounted for about four-fifths of the 1986 increase. Taken together, oil production in OPEC and the other market economies jumped nearly 4.5 percent to 45.8 million barrels per day. Non-OPEC developing countries such as Mexico generally maintained steady production for the export market. However, lower crude oil prices in 1986 appear to have halted 10 years of growth in non-OPEC crude oil supplies. Production in the centrally planned economies remained steady at about 16 million barrels per day.

World Oil Prices

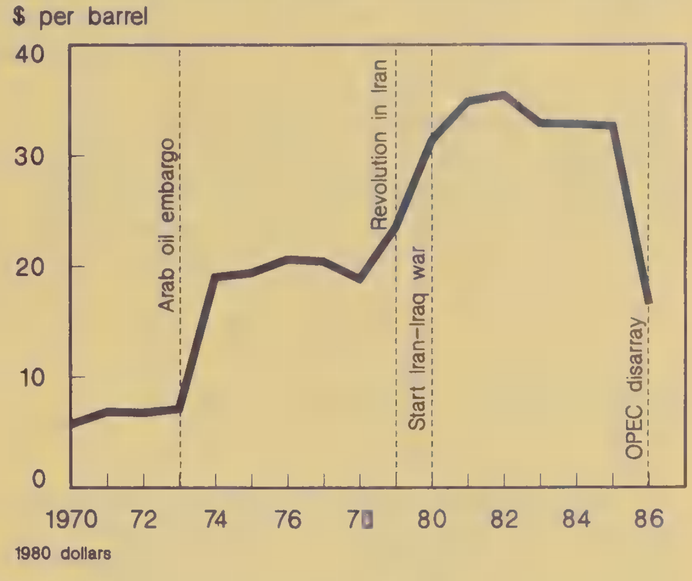
Average world oil prices (f.o.b. weighted by trade volume) plunged 50 percent in 1986, to the lowest level in real terms since 1973 when the first oil price shock occurred. A variety of factors contributed to the continued erosion of OPEC control of prices. On the supply side, these factors include relatively higher non-OPEC production, cheating on production quotas, increased world oil reserves, and enhanced oil recovery techniques. On the demand side, the factors include relatively slow economic growth in the developed countries compared with historical trends, energy conservation, and substitution of other energy sources for oil. Even though the effectiveness of OPEC agreements reached in 1986 remains open to question, given the lingering internal disputes over production quotas and price targets, 1986 OPEC production levels at less than 50 percent of capacity remain far below levels of the 1970's.

Soft oil prices contributed to low inflation, but regions heavily dependent on oil revenue suffered economically. These regions included diverse areas such as Indonesia, OPEC, North Sea oil countries, Mexico, western Canada, and in the United States, Texas, Alaska, Louisiana, east-central California, and Oklahoma. In many energy-importing less developed countries, foreign exchange savings from less costly imported oil encouraged domestic growth and import demand for non-oil commodities, including agricultural products.

World crude oil prices in 1986 were characterized by instabilities and changes in the way prices are set. At the beginning of the year, crude oil sold for more than $25 per barrel, sliding to lows of $10 per barrel in March and July and cresting near $15 in May and August. The year ended with the average world crude oil price hovering at close to $16 per barrel. In the United States, refiners' costs of imported crude oil averaged $14.60 per barrel in 1986, more than a one-third drop from 1985.

Due to netback arrangements initiated by Saudi Arabia, where crude oil prices are tied to specific refiners' margins, oil and petroleum product price movements became more consistent in 1986. Over the past year, commercial terms (including netback, spot, or formulas tied to spot prices) based on current market conditions rather than long-term price agreements accounted for about 90 percent of international crude oil trade compared to only 30 percent in 1985.

Weighted Average World Crude Oil Prices



Free world discretionary stocks--not including the Strategic Petroleum Reserve (SPR)--stood at 20 days' worth of consumption at the end of 1986, which is substantially higher than the normal 12 days.

Outlook for 1987

World demand for petroleum products is likely to increase nearly 2 percent in 1987, with modest growth in economic activity offsetting a possible increase in energy prices. This expected increase in demand reverses several years of decline. The December 1986 agreement by OPEC to cut production by 7 percent to 15.8 million barrels per day during the first half of 1987 and to target a price of $18 per barrel may add a degree of stability to the world oil market. However, weak financial conditions in individual OPEC countries are likely to encourage policymakers there to increase oil revenues, increasing the likelihood that the cartel members will produce beyond their quotas and fail to insure that the $18 price will hold. The large inventories in consuming nations put added downward pressure on OPEC crude oil prices.

If OPEC's December price/quantity agreement appears relatively workable and industry holds onto stocks, market conditions during the first half of 1987 will be relatively orderly. Continuation of low crude oil prices at about $16 per barrel will support modest economic growth in developed countries, strong growth in oil importing developing countries with high agricultural import bills, and balance of payments problems for many oil exporters.

U.S. Energy Outlook

Imports Surge as Domestic Petroleum Supplies Slide

With surging crude oil imports more than offsetting a falloff in domestic crude production, total U.S. petroleum supplies increased 3 percent to more than 16 million barrels per day in 1986. Supplies in 1987 are projected to increase only 1 percent as markets work down current stocks (table 33).

Domestic petroleum production, which includes crude oil, natural gas liquids, and other petroleum products, decreased 2 percent to an estimated 11 million barrels per day in 1986. Most of the decrease was due to a 170,000-barrel-per-day drop in crude oil production to an estimated 8.8 million barrels per day, despite a pickup in Alaskan output. The decline was driven by sliding oil prices, which forced high-cost, low-yield stripper wells to close and maintenance and development activity on existing fields to decline. Domestic production in 1987 is expected to fall another 170,000 barrels per day, encouraging even higher oil imports.

Net petroleum imports, excluding those for the SPR, jumped 22 percent to 5.1 million barrels per day in 1986 (table 33). In 1987, these imports, because of plentiful stocks, are projected to increase only slightly to 5.3 million barrels per day. The share of total petroleum supplies attributable to net imports (excluding SPR) is estimated at 32 percent in 1986, compared to only 27 percent in 1985. The share is expected to increase to 33 percent in 1987, still far below the levels of 1979 and 1980, during the second oil price shock. Nonetheless, falling domestic production in the United States and increasing imports in 1986 and 1987 will undoubtedly

Table 33--U.S. petroleum consumption-supply balance

Item	1983	1984	1985	Preliminary 1986	Forecast 1987
			Million barrels per day		
Consumption:					
Motor gasoline	6.62	6.69	6.83	7.02	7.00
Distillate fuel	2.69	2.84	2.87	2.90	3.03
Residual fuel	1.42	1.37	1.20	1.38	1.25
Other petroleum 1/	4.50	4.82	4.83	4.86	5.08
Total	15.23	15.72	15.73	16.16	16.36
Supply:					
Production 2/	10.79	11.17	11.26	11.08	10.89
Net imports (excludes SPR)	4.08	4.52	4.17	5.10	5.32
Net stock withdrawals	.25	-0.08	0.22	-0.14	0.09
Total	15.12	15.61	15.65	16.04	16.30
Net imports as a percent of total supply	27.00	29.00	27.00	32.00	33.00
			Percent change from previous year		
Consumption		3.2	0.1	2.7	1.2
Production		3.5	0.9	-1.6	-1.7
Net imports		10.8	-7.7	22.3	4.3

SPR = Strategic Petroleum Reserves.

1/ Includes crude oil, pentanes plus, other hydrocarbons, and alcohol, unfinished oil, gasoline blending components and jet fuel. 2/ Includes domestic crude oil production, natural gas liquids, and other petroleum products.

increase public debate in the coming year on the desirability of some form of import tariff or excise tax, or alternatively, on relaxation of the windfall profits tax and other fiscal incentives to producers.

Petroleum Consumption Up in 1986, Smaller Increase Likely in 1987

Boosted by favorable prices and modest income growth, total U.S. consumption of petroleum products rose nearly 3 percent to an estimated 16.2 million barrels per day in 1986, led by increased gasoline and residual fuel oil use (table 33). Compared with a large price decline, the increased consumption was relatively small due to continued conservation and vehicle efficiency. Total petroleum consumption in 1987 is forecast to rise only 1 percent from last year, restrained by a moderate increase in oil prices, less switching from natural gas to oil, and smaller improvements in vehicle efficiency (table 33).

Consumption by Type of Fuel

Gasoline consumption in 1986 increased 3 percent to about 7 million barrels per day, as travel jumped 5 percent, encouraged by lower gasoline prices, higher personal income, and more U.S. vacations due to terrorism abroad. The relatively small increase in gasoline consumption---considering the significant price drop---is traceable to a more than 3-percent increase in mileage per gallon in 1986. Gasoline consumption is projected to remain unchanged in 1987 with slightly higher prices offsetting modest personal income growth. Also, growth in vehicle miles traveled is projected to slow to 2.6 percent.

Consumption of distillate fuel oil, which consists of diesel fuel and heating oil, increased about 1 percent to an estimated 2.9 million barrels per day in 1986. The small increase, despite sharply lower prices, was due to sluggish industrial activity. Consumption in 1987 is projected to rise more than 4 percent, with about a 3-percent increase in industrial activity outweighing the dampening effect of a moderate increase in oil prices on nonheating demand. Residential consumption of heating oil is expected to change little in 1987. Residential demand is more responsive to changes in degree days than to changes in fuel oil prices, as very little switching is possible in the short run. Supply problems are not anticipated because refinery production and readily available imports should be adequate to meet any unexpected increase in demand.

In 1986, total consumption of residual fuel oil, which includes heavy oil used primarily for electric power generation and commercial space heating, increased an estimated 15 percent, reversing an 8-year decline. A 41-percent drop in the price of residual fuel oil prompted the substitution of residual fuel for natural gas, primarily by electric utilities. Utility consumption of residual fuel oil, about two-fifths of the total, increased an estimated 34 percent. In contrast, nonutility consumption among industrial and commercial users remained flat, reflecting limited flexibility for inter-fuel substitution. In 1987, residual fuel oil demand by electric utilities is expected to fall 22 percent and reverse much of 1986's gain due to increased generation from coal and nuclear power. However, total residual fuel oil consumption, with nonutility consumption holding steady, is projected to slide only 9 percent.

Natural Gas Competitive Position To Improve in 1987

In 1986, natural gas consumption declined 4 percent to an estimated 16.5 trillion cubic feet. The decline was led by a 15-percent drop in demand from electric utilities, which substituted oil for relatively more expensive natural gas. The price of natural gas to electric utilities dropped about 27 percent, considerably less than the 42-percent drop in oil product prices. Because fuel switching options are more limited, the fall in natural gas use in all other areas was only about 2 percent. In 1987, the competitive position of natural gas, especially in residential and commercial uses, is likely to improve if oil prices increase slightly relative to natural gas prices as projected. Total natural gas consumption is expected to increase about 2 percent.

Natural gas production decreased more than 1 percent to an estimated 16.2 trillion cubic feet in 1986, and will likely remain near that level in 1987. Net imports of natural gas, mostly from Canada, dropped 23 percent to about 700 billion cubic feet because of lower U.S. prices, but are projected to increase by 12 percent in 1987, as prices increase

moderately. Regulations implemented in 1986 to free up domestic natural gas markets have forced Canadian producers to become more competitive to maintain their U.S. market share.

Electricity--Slight Recovery in Demand in 1987

Electricity generation increased only about 1 percent to 2,492 billion kilowatt-hours in 1986 due to sluggish demand from the industrial sector. Growth of 2 percent is expected in 1987 as industrial activity picks up.

The price of electricity increased about 1 percent in 1986, following a 4-percent rise in 1985. The slower increase was due to lower prices paid by electric utilities for fuels, especially residual fuel oil and natural gas. Lower fuel and interest costs are expected to offset higher costs of capital additions. Electricity prices are expected to increase another 1 percent in 1987. Net electricity imports, nearly all from Canada, have been rising since the late 1970's. Total net imports were projected to rise to 44 billion kilowatt-hours in 1986, 3 billion kilowatt-hours over 1985. A further increase of 3 billion kilowatt-hours is projected in 1987. The gain will be mainly due to the opening of transmission facilities between Quebec, Canada, and New England in second-half 1986.

Energy in the Farm Sector

The agriculture sector's energy supply and price expectations largely reflect world market conditions, which are characterized by plentiful oil supplies and the lowest prices since 1979-80. Farmers can expect this favorable situation to continue for the near future.

Expenditures and Use Likely To Fall in 1987

Farm energy expenditures in the 1970's rose dramatically because of skyrocketing energy prices and increased planted acreage. Expenditures have been declining since 1981 because of lower energy prices, energy conservation efforts, and reductions in planted acreage due to greater farmer participation in various commodity programs.

Table 34--Farm energy expenditures

	1984	1985	Preliminary 1986	Forecast 1987
	Million dollars			
Fuels and oil	7,118	6,584	5,176	4,793
Electricity	2,167	2,073	2,115	2,178
Total	9,285	8,657	7,291	6,971
Percent change from preceding year		-7	-16	-4

In 1986, farm energy expenditures dropped 16 percent to $7.3 billion while use dropped only 4 percent, largely because of a reduction in planted acreage and the continued adoption of energy-conserving tillage practices (table 34). Fuel use in 1987 is projected to decline another 2 percent due to an anticipated drop in planted acreage. Expenditures in 1987 are projected to decline another 4 percent, representing the sixth consecutive decline and a situation that is unprecedented since the 1930's.

Prices

In 1986, following the sharp decline in world oil prices, farm gasoline, diesel fuel, and LP gas prices fell sharply. In October 1986, gasoline prices averaged 82 cents a gallon, compared with $1.16 a year earlier---a drop of 29 percent. Also in October 1986, diesel fuel prices averaged 62 cents a gallon, compared with 97 cents in October 1985--a decline of 36 percent. Likewise, LP gas prices were 13 percent lower than October 1985 (table 35). The October 1986 index of fuel and energy prices, at 154, was at its lowest level since September 1979.

LAND VALUES

The drop in land values appears to be moderating, but is expected to continue in 1987. Expected changes in values in 1987 show decreases throughout the Corn Belt, Southeast, Southwest, and Pacific Northwest. Decreases are expected for both irrigated and nonirrigated cropland, pasture and rangeland. Most respondents expected larger declines for marginal land than for more productive acreage.

U.S. farmland values declined 12 percent from April 1985 to February 1986. Although the largest decreases were reported in the Lake States, Southern Plains, and Delta, values fell in all regions except the Northeast. The downward trend that began in the early 1980's left the February 1986 national average land value at $596 per acre, down from the peak of $823 in 1982. Results of various surveys for 1986 conducted by ERS, land grant universities, Federal Land Banks, and Federal Reserve Banks indicate the downward trend in land values continued, but at a slower rate than the change from 1985 to 1986. The ERS estimate of changes in land values for 1986 will be available in April 1987.

Table 35--Average U.S. farm fuel prices 1/

Year	Regular gasoline	Diesel fuel	LP gas
	Dollars per gallon 2/		
1977	.57	.45	.39
1978	.60	.46	.40
1979	.80	.68	.44
1980	1.15	.99	.62
1981	1.29	1.16	.70
1982	1.23	1.11	.71
1983	1.18	1.00	.77
1984	1.16	1.00	.76
1985			
Jan	1.09	.96	.74
Apr	1.15	.97	.73
Jul	1.19	.94	.72
Oct	1.16	.97	.71
1986			
Jan	1.14	1.00	.74
Apr	.84	.70	.67
Jul	.84	.59	.64
Oct	.82	.62	.62

1/ Based on surveys of farm supply dealers conducted by the National Agricultural Statistics Service, USDA. 2/ Bulk delivered.

There are some positive forces in the land market, including decreasing interest rates and production costs and increasing farm income because of Government payments. Also, low rates of return on alternative investments may make farmland more attractive at current prices. However, negative factors such as the large acreage of land for sale relative to the demand, financial difficulties of some lenders, and uncertainty over future farm programs will put downward pressure on values for the remainder of the year. [*William Henneberry (202) 786-1428*]

Appendix table 1--U.S. fertilizer imports: Declared value of selected materials for years ending June 30

Material	1984	1985	1986	1987 1/
	Million dollars			
Nitrogen:				
Anhydrous ammonia	443	414	348	100
Urea	255	259	299	106
Ammonium nitrate	55	55	55	12
Ammonium sulfate	27	32	26	6
Sodium nitrate	11	15	13	3
Calcium nitrate	14	13	11	5
Nitrogen solutions	31	21	27	10
Other	17	27	23	7
Total 2/	853	836	802	249
Phosphate:				
Ammonium phosphates	35	34	24	7
Crude phosphates	*	*	14	6
Phosphate acid	*	*	*	*
Normal and triple superphosphate	1	1	*	*
Other	1	*	*	*
Total 2/	38	36	39	14
Potash:				
Potassium chloride	603	588	406	125
Potassium sulfate	12	12	9	2
Potassium nitrate 3/	7	11	15	4
Total 2/	623	611	430	131
Mixed fertilizers	25	27	22	4
Total 2/	1,539	1,510	1,292	398

* = Less than $1 million.

1/ Preliminary data for July-November 1986.
2/ Totals may not add due to rounding. 3/ Includes potassium sodium nitrate.

Source: (6).

Appendix table 2--U.S. fertilizer exports: Declared value of selected materials for years ending June 30 1/

Material	1984	1985
	Million dollars	
Nitrogen:		
Anhydrous ammonia	59	162
Urea	127	208
Ammonium nitrate	4	5
Ammonium sulfate	36	55
Sodium nitrate	3	4
Nitrogen solutions	2	*
Other	4	4
Total 2/	235	438
Phosphate:		
Phosphate rock	427	370
Normal superphosphate	*	*
Triple superphosphate	142	185
Diammonium phosphate	933	1,277
Other ammonium phosphates	89	86
Phosphoric acid	352	404
Total 2/	1,944	2,322
Potash:		
Potassium chloride	46	66
Potassium sulfate	17	14
Other	28	25
Total 2/	91	105
Mixed fertilizers	29	18
Total 2/	2,299	2,884

* = Less than $1 million.

1/ Declared value of exports by selected materials are not reported after June 1985. 2/ Totals may not add due to rounding.

Source: (5).

Appendix table 3--Plant nutrient use by State for years ending June 30 1/

State, region	1985			1986		
	Nitrogen	Phosphate	Potash	Nitrogen	Phosphate	Potash
	Thousand tons					
Maine	13	12	12	12	10	10
New Hampshire	3	2	3	3	2	3
Vermont	8	7	10	6	5	7
Massachusetts	9	6	8	11	5	8
Rhode Island	2	1	1	2	1	1
Connecticut	6	5	6	8	4	5
New York	97	78	107	71	70	104
New Jersey	29	18	22	26	16	19
Pennsylvania	69	55	56	57	47	49
Delaware	21	8	17	17	7	14
Maryland	56	38	48	49	33	42
NORTHEAST....................	312	229	288	262	200	264
Michigan	285	174	282	248	143	243
Wisconsin	282	155	391	258	136	339
Minnesota	644	283	375	553	230	289
LAKE STATES................	1,211	612	1,048	1,059	508	871
Ohio	350	192	314	405	206	346
Indiana	569	280	473	483	252	437
Illinois	1,028	487	717	951	465	701
Iowa	1,129	369	545	934	313	451
Missouri	367	146	215	348	148	224
CORN BELT...................	3,443	1,474	2,264	3,120	1,383	2,160
North Dakota	269	126	25	323	145	24
South Dakota	133	62	17	136	74	21
Nebraska	806	147	42	748	145	39
Kansas	629	185	42	545	140	33
NORTHERN PLAINS..............	1,837	521	126	1,751	504	116
Virginia	99	67	91	82	55	78
West Virginia	13	13	14	10	10	11
North Carolinia	246	124	216	207	105	182
Kentucky	190	122	142	180	112	137
Tennessee	140	96	122	130	83	114
APPALACHIA...................	687	422	585	610	365	521
South Carolina	98	44	91	83	35	72
Georgia	249	118	189	219	99	158
Florida	215	95	237	231	88	221
Alabama	157	74	90	133	59	78
SOUTHEAST....................	720	331	607	665	281	529
Mississippi	172	61	81	170	61	80
Arkansas	207	59	82	208	55	79
Louisiana	170	60	81	179	48	66
DELTA STATES.................	548	180	243	557	163	225
Oklahoma	280	104	35	261	86	32
Texas	830	261	134	714	216	114
SOUTHERN PLAINS..............	1,110	364	169	975	302	146
Montana	110	77	12	82	62	10
Idaho	182	71	21	158	60	15
Wyoming	22	7	1	18	8	1
Colorado	173	34	14	196	30	12
New Mexico	41	14	5	34	14	7
Arizona	94	27	1	79	25	2
Utah	2/	2/	2/	2/	2/	2/
Nevada	5	3	*	4	2	*
MOUNTAIN.....................	626	232	54	572	201	48
Washington	218	55	38	194	50	34
Oregon	138	40	25	134	38	24
California	610	180	73	508	148	60
PACIFIC	966	276	136	836	236	118
48 STATES AND D.C............	11,488	4,640	5,520	10,406	4,143	4,996
Alaska	3	2	1	2	1	1
Hawaii	19	11	20	17	10	19
Puerto Rico	13	5	11	14	6	12
U.S. TOTAL...................	11,483	4,658	5,553	10,439	4,160	5,028

* = Less than 500 tons. 1/ Totals may not add due to rounding. Fertilizer use estimates for 1976 to 1984 are based on USDA data, while 1985 and 1986 are TVA estimates. 3/ Not available.

Appendix table 4--Fertilizer use on corn, 1986

State	Acres planted	Fields in survey	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P_2O_5	Acres receiving: K_2O	Application rates: N	Application rates: P_2O_5	Application rates: K_2O	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	Thousand	No.	Percent				Pounds			Percent		
Michigan	2,900	99	100	99	97	95	119	58	90	58	1	41
Minnesota	6,400	174	96	95	90	85	107	48	62	80	1	19
Wisconsin	3,900	153	97	97	97	95	86	53	70	74	1	37
Total	13,200	426	97	97	94	91	104	52	71	73	1	26
Illinois	10,500	239	97	97	86	82	156	79	105	79	1	20
Indiana	6,000	163	99	99	95	86	157	75	113	55	1	44
Iowa	12,300	204	99	98	83	81	131	57	66	76	5	19
Missouri	2,550	129	98	97	77	75	133	58	66	79	9	12
Ohio	3,900	166	98	98	93	92	154	73	102	41	3	56
Total	35,250	906	98	98	87	83	146	69	90	67	3	30
Nebraska	7,200	193	93	93	62	37	141	36	22	65	10	25
South Dakota	3,200	119	75	75	60	31	73	38	23	81	9	10
Total	10,110	312	86	86	60	34	123	37	22	70	9	21
10 State total	58,850	1,644	96	95	84	76	132	61	80	69	4	27

Appendix table 5--Fertilizer use on cotton, 1986

State	Acres planted	Fields in survey	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P_2O_5	Acres receiving: K_2O	Application rates: N	Application rates: P_2O_5	Application rates: K_2O	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	Thousand	No.	Percent				Pounds			Percent		
Missouri	180	56	100	100	82	88	57	48	63	36	25	39
Tennessee	300	99	100	100	100	100	75	65	71	68	0	32
Alabama	350	99	99	99	87	77	82	57	62	58	0	42
Georgia	230	52	92	92	87	90	80	55	88	17	13	70
South Carolina	115	53	96	96	77	85	84	58	96	8	12	80
Total	695	204	97	97	84	82	82	56	77	35	6	59
Arkansas	460	104	99	99	68	81	84	39	65	36	11	53
Louisiana	600	93	100	100	72	73	95	43	48	46	24	30
Mississippi	1,050	160	98	96	39	49	102	54	63	50	14	36
Total	2,110	357	99	98	56	64	96	46	59	45	16	39
Oklahoma	370	99	47	46	39	25	29	29	15	78	22	0
Texas	4,418	534	56	56	44	18	45	35	13	66	23	11
Total	4,788	633	55	54	43	19	44	34	13	68	22	10
Arizona	333	97	93	93	39	7	122	47	12	16	56	28
New Mexico	60	65	49	49	28	3	54	60	6	63	21	16
Total	393	162	75	75	35	6	116	49	12	28	47	25
California	1,020	260	92	92	16	2	104	62	24	32	43	25
13 State total	9,486	1,771	80	80	50	39	77	44	50	47	23	30

Appendix table 6--Fertilizer use on soybeans, 1986

State	Acres planted	Fields in survey	Acres receiving				Application rates			Proportion fertilized		
			Any fertilizer	N	P_2O_5	K_2O	N	P_2O_5	K_2O	At or before seeding	After seeding	Both
	Thousand	No.	Percent				Pounds			Percent		
Minnesota	5,000	93	11	10	9	10	13	20	42	90	10	0
Illinois	9,000	182	23	9	17	22	14	45	88	100	0	0
Indiana	4,300	108	38	16	31	37	11	49	84	100	0	0
Iowa	8,700	148	10	6	8	10	14	51	62	100	0	0
Missouri	5,700	146	23	8	19	23	14	46	69	100	0	0
Ohio	3,700	112	56	23	41	55	14	42	81	95	5	0
Total	31,400	696	28	11	21	27	13	46	80	98	2	0
Nebraska	2,500	88	19	15	18	7	14	27	10	100	0	0
Kentucky	1,100	90	59	42	59	56	27	63	70	98	2	0
North Carolina	1,700	84	58	46	52	57	13	36	70	100	0	0
Tennessee	1,550	81	48	22	47	48	18	44	57	100	0	0
Total	3,250	255	55	37	53	54	18	46	66	99	1	0
Alabama	780	78	68	44	68	59	21	48	57	100	0	0
Georgia	1,250	64	81	50	77	77	17	37	64	94	6	0
Total	2,030	142	74	50	72	67	18	41	62	97	3	0
Arkansas	3,700	136	18	7	15	17	14	39	58	96	4	0
Louisiana	1,950	99	23	3	23	22	17	45	62	100	0	0
Mississippi	2,600	111	24	8	19	23	16	44	65	100	0	0
Total	8,250	346	21	6	19	21	15	42	61	99	1	0
15 State total	52,430	1,620	33	18	29	31	15	43	71	98	2	0

Appendix table 7--Fertilizer use on wheat, 1986

State	Acres planted	Fields in survey	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P_2O_5	Acres receiving: K_2O	Application rates: N	Application rates: P_2O_5	Application rates: K_2O	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	Thousand	No.	Percent				Pounds			Percent		
Minnesota	3,065	68	99	99	90	62	76	40	32	96	1	3
Illinois	1,300	79	87	87	77	65	72	80	92	33	12	55
Indiana	900	61	92	77	90	89	77	49	60	38	5	57
Missouri	1,050	92	80	80	70	75	73	44	65	48	18	34
Ohio	1,150	71	90	99	85	87	72	63	74	14	20	66
Total	4,400	303	89	86	79	78	73	61	73	33	14	53
Arkansas	850	69	94	90	41	42	112	39	45	8	55	37
Kansas	11,500	270	79	79	42	6	59	33	31	66	10	24
Nebraska	2,300	102	71	70	21	4	46	33	17	60	30	10
North Dakota	9,320	250	81	81	70	7	44	27	14	98	1	1
South Dakota	4,065	50	68	68	44	6	46	26	14	97	3	0
Total	27,185	672	78	78	49	6	51	30	21	80	9	11
Oklahoma	7,400	185	81	81	43	9	64	37	27	54	13	33
Texas	8,100	185	44	43	26	7	68	35	18	57	20	23
Total	15,500	370	65	64	36	8	65	36	22	55	15	30
Colorado	3,360	100	64	64	11	1	42	26	10	89	8	3
Idaho	1,430	148	88	88	51	8	89	39	27	43	27	30
Montana	5,150	176	59	59	53	5	30	28	11	81	4	15
Total	9,940	424	71	71	39	5	46	30	16	66	15	19
California	730	76	91	91	54	1	121	42	10	46	3	51
Oregon	1,090	94	96	96	20	12	79	31	42	61	10	29
Washington	2,580	161	96	96	30	4	73	24	15	85	2	13
Total	4,400	331	95	95	33	5	82	30	30	70	4	26
18 State total	65,340	2,237	79	79	48	19	60	36	44	63	12	25

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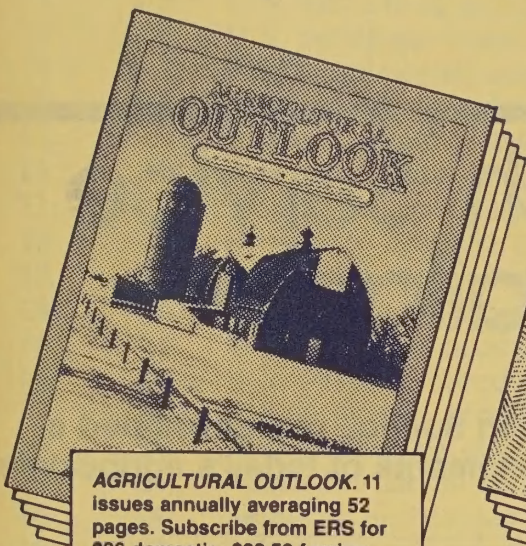

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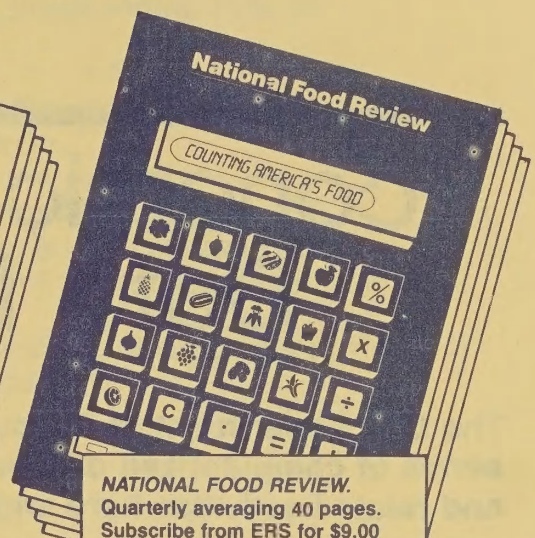

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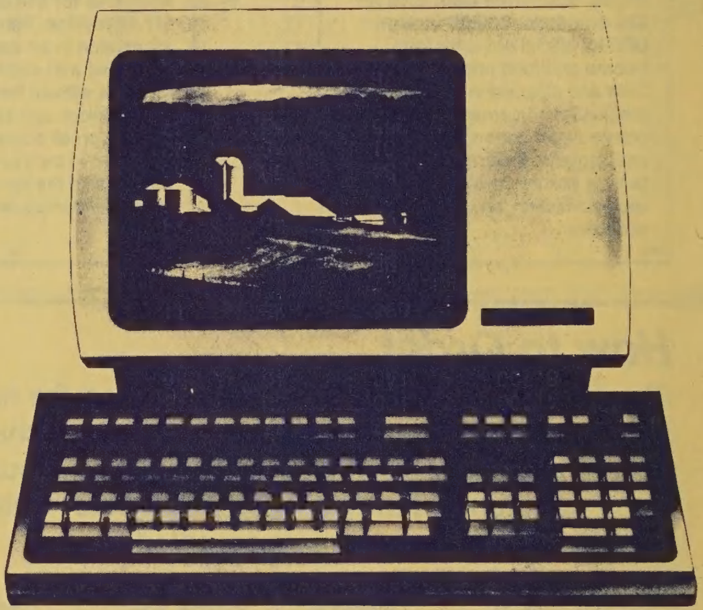

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